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Pacific Northwest Region

Final Environmental Impact Statement

Management of Western Spruce Budworm in Oregon and Washington

Final Environmental Impact Statement for

Managing Western Spruce Budworm In Oregon And Washington

USDA Forest Service
Pacific Northwest Region
States of Oregon and Washington and Portions of California and Idaho

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Abstract

The Forest Service, in compliance with the National Environmental Policy Act of 1969, is presenting four alternative methods of managing the western spruce budworm in the Pacific Northwest on lands administered by the Forest Service, Bureau of Land Management, Bureau of Indian Affairs, and on private lands in cooperation with the States of Oregon and Washington in federally funded cost share programs.

The alternatives are:

A. No action, manage the western spruce budworm infestation without the use of insecticides.

B. Direct suppression with the use of the biological insecticide *B.t.* only. This alternative allows the Forest Service to cost-share with States using *B.t.*, but not the insecticide carbaryl.

C. Direct suppression with the use of chemical insecticides only. This alternative allows the Forest Service to cost-share with States using the insecticide carbaryl.

D. Direct suppression with the use of *B.t.* and/or the chemical insecticide carbaryl. This alternative allows the Forest Service to cost-share with States using *B.t.* and/or carbaryl.

E. Direct suppression using *B.t.* as the primary treatment option, allowing for the use of carbaryl only under extraordinary circumstances. This alternative allows the Forest Service to cost-share with States using *B.t.* and/or carbaryl.

Alternative E is the Forest Service's Preferred Alternative.

The effects of the alternatives on the physical and biological environment, human health, social and economic conditions, and resource management are presented.

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SUMMARY

Introduction

The Pacific Northwest Region (Region 6) of the USDA Forest Service is headquartered in Portland, Oregon. It includes Oregon, Washington, and parts of a few Counties in California and Idaho. In Region 6, the Forest Service administers 19 National Forests (including 1 National Grassland) totaling 24.5 million acres. Terrain and vegetation vary widely across the Region. There is a great variety of landforms, from coastal dunes and flat grasslands to rolling hills, steep ridges, mountains, and volcanoes. Natural vegetation ranges from the Olympic rain forest to interior high deserts.

This summary of the Environmental Impact Statement (EIS) discusses the issues and concerns raised by the public and other agencies, and Forest Service personnel regarding management of the current western spruce budworm infestation. After carefully considering comments, the Final Environmental Impact Statement has been prepared and issued. This final version is the basis for selection of a program for managing future western spruce budworm infestations in National Forests in the Pacific Northwest.

Current Situation

Various plant communities on the east side of the Cascade Range have been experiencing an ongoing infestation of western spruce budworm. Douglas-fir, grand fir, white fir, Engelmann spruce, subalpine fir, and western larch are the primary source of food for western spruce budworm. The spruce budworm is capable of consuming and destroying much of the new foliage on these trees. The result is vast areas of brown defoliated trees, some of which could eventually die. Although western spruce budworm is always present in the forest, a high level of budworm activity has been reached and the associated damage has caused considerable concern to forest landowners and other National Forest users. Efforts to control the current infestation could have important consequences on the social, biological, and physical environment.

Description Of The Insect

The western spruce budworm, (*Choristoneura occidentalis* Freeman), is the most widely distributed defoliator and potentially destructive insect of coniferous forests in western North America. The adult is a small orange-brown mottled moth. The destructive feeding period is during the caterpillar (larval) stage of the insect. The insect's population levels are usually held in check by the interaction of parasites, predators, timber stand conditions, and weather. Periodically, the complex of natural controls no longer limits growth of budworm numbers and an outbreak occurs.

At epidemic levels, budworms may defoliate entire timber stands, feeding primarily upon new needle growth. Outbreaks typically last from 6 to 10 years, resulting in five types of damage to host trees: growth loss, top-kill, deformity, reduced seed production, and mortality.

In Oregon and Washington, the budworm completes one cycle of development from egg to adult each year. Following flight in late July and August, the adult moths lay eggs that soon develop into tiny larvae which overwinter in an inactive state in sheltered places under bark scales and among lichens on tree boles or limbs. In early May to late June, larvae emerge and begin their active feeding stage. As rapidly growing larvae, spruce budworms molt (shed their skin) a total of five times. The six intervening stages are called instars. After about 30 to 40 days, larvae develop into pupae. The moths emerge from the pupae after about 10 days to begin the cycle again.

Scope of the Decision

The scope of considerations described in this EIS will provide the responsible official with a basis for deciding which strategy, if any, should be used to manage the current epidemic of budworm infestation.

During the public involvement process, concern was expressed as to what could be done to reduce damaging infestations long term. These solutions consist of silviculture manipulation of a stands

composition to reduce the amount of host species present. Generally, the USDA Forest Service is in agreement with the use of these means. However, the spruce budworm is only one of many insects and diseases to be considered in management strategies for dealing with the future health of forests. Complex interactions of forest insects and diseases exist in all forest plant communities. A management strategy for control of one insect or disease may increase or decrease the effects of other insects and diseases. It may also effect the needs or outputs of other forest resources.

The Forest Service does not presently have the computer modeling capability to make long-term strategic decisions for management of the insects and disease complex. In addition, techniques do not exist to integrate these decisions with resource allocation decision that are made during development of the Forest Plans. The Forest Service is committed to have this capability within the foreseeable future.

In addition, silviculture solutions will take decades to implement and thus, be ineffective towards the present infestation. Since the scope of this EIS is limited to treatment of the current infestation, long term silviculture treatments were precluded from consideration.

The decision which is reached from consideration of this FEIS will be applied to areas throughout the Pacific Northwest Region, where direct suppression of western spruce budworm infestations appears to be warranted. Site specific analyses will be conducted within individual management units, to consider the possible effects of proposed treatments. Environmental analysis will be conducted and the appropriate disclosure documents prepared.

Public Involvement

Meetings to help identify public concerns have been conducted with Government agencies, Special interest groups, industry representatives, and interested individuals.

A scoping brochure requesting comments and concerns was mailed to approximately 2,000 groups and individuals to help identify Issues and concerns. Press releases were mailed to the media near areas where western spruce budworm infestations have been documented. A total of 206 responses were received through distribution of the brochure and included approximately 550 substantive comments. These comments were analyzed to identify issues, proposed Alternatives, and viable analysis criteria needed to evaluate the possible Alternatives.

In October 1988, a Draft Environmental Impact Statement (DEIS) on the management of the western spruce budworm in Oregon and Washington was printed. Approximately 1000 copies of the DEIS and 2000 copies of a Summary were mailed to interested parties. A total of 101 responses were received through distribution of the DEIS and Summary and included approximately 1244 substantive comments. These comments were incorporated into the Final Environmental Impact Statement.

Major Issues And Concerns

In the years since 1981, when budworm infestations reached readily verifiable epidemic proportions in the Region, Environmental assessments (EAs) have documented a growing concern for affected resources and for the effects of chemical suppression efforts. Issues and concerns identified during a 1984 northeastern Oregon analysis were used to help generate public involvement in 1985. 'Scoping' efforts in 1986 included public meetings and written inquiries to concerned citizens. In 1986, 1987, and 1988, public meetings were held by individual Forests. In addition, letters were written to interested parties, to elicit and identify issues and concerns that had not been specifically addressed in previous EAs. Public meetings, personal interviews, news clippings, and written correspondence resulted in identification of public issues and management concerns. The Issues identified by these means reflect the views of concerned individuals, forest-based industry representatives, landowners of various-sized forest holdings, forest resources user groups, conservation and environmental groups, Native American tribes; as well as representatives of local, State, and Federal agencies and governments.

Based on responses to mailed inquiries; and concerns identified in a broad sampling of past EAs, major public Issues were identified in the scoping process conducted for this EIS. A discussion of these issues follows:

Silviculture

The effects of budworm infestations on timber production are complex, whether treatment is initiated or not. Long-term management of timber stands through silviculture treatments as a means to end the epidemic is an Issue. Western spruce budworm suppression efforts would only serve to lessen short-term growth losses. However, any long-term solution will take decades to implement and thus ineffective in treating the present outbreak.

Concern has been expressed that untreated budworm infestations may negate efforts to increase timber growth rates through intensive timber management, and that long-term yields and harvests may be reduced from present levels. It has been suggested that budworm suppression using insecticides will be needed until areas contain healthy, mixed-species stands which are less vulnerable to budworm infestation. There is concern that past silvicultural practices have led to species composition and stand conditions that are more vulnerable to spruce budworm infestations and resulting damage.

Water Quality/Quantity

Two broad areas of concern are included in this issue: possible hydrologic changes that might occur in watersheds if the budworm epidemic is left unchecked, and possible contamination of water quality from the use of insecticides. Some members of the public have asserted that widespread defoliation may result in variations in the quantity of water yield in heavily affected watersheds; that increased flows could result in streambank cutting and greater sediment loads. Hydrologic changes could also affect unstable slopes and cause increased mass failure activity.

A number of people are concerned about monitoring activities. They believe that monitoring should be adequate to assess the short-term and long-term effects of treatment on water quality and riparian zones.

Most concern about possible water quality diminution centers on the use or accidental spills of chemical insecticides. The nature of ingredients in *B.t.* formulations and the use of spreader/sticker agents in this biological insecticide are also a concern. Individuals have expressed concern about possible adverse effects on aquatic life and irrigation water. However, the central issue involves direct human use of water that may contain insecticides. Protection of water quality in Oregon and Washington municipal watersheds, such as those of The Dalles, Dufur, and Walla Walla, is of great concern.

Fire and Fuels

Many years of effective fire suppression have resulted in unprecedented accumulations of needle litter, dead limbs, and dead trees; which can lead to high intensity wildfires. Infestations of mountain pine beetle, western spruce budworm, and Douglas-fir tussock moth have also contributed to fuel loads. Recent insect epidemics have increased the rate of accumulation.

Fish, Wildlife, and Domestic Animals

People are concerned that fish, wildlife and domestic animals could be adversely affected by the budworm infestation or by insecticide application.

Big game species may be affected if budworm defoliation changes the quantity and/or quality of the coniferous overstory which is used for thermal cover, hiding, and escape. Some people expressed concern that deer and elk may be adversely affected by ingesting insecticides on forage. Since spraying of insecticides usually occurs about the same time as spring birthing, some people express concern about the effects of increased human disturbance (increased desertion of young, increased vulnerability to predation) during this critical biological activity. Bighorn sheep deserting their young as a result of human disturbance was a concern mentioned in particular.

Concerns were also expressed about possible adverse effects of insecticides on vertebrate species (birds, small rodents, and squirrels) that consume budworms and other insects. While insectivorous bird species were mentioned most often in this regard, concern was also expressed for several species of raptors, geese, flying squirrels, bats, toads, lizards, salamanders, and snakes. Other concerns were expressed for federally classified threatened or endangered species, and that a reduction in food supply for several species could cause relocation and reduction in nestling survival.

Concerns were expressed about possible adverse effects of insecticides on natural predators of the budworm, which might upset the natural balance and result in a need for yearly treatment. Possible adverse effects on pollinator species and livestock were also a concern.

Many people expressed a strong desire for monitoring programs to better assess the direct and secondary effects of insecticide application on nontarget species. These data would then provide a better source of information upon which to base future budworm suppression decisions.

The same concerns described for terrestrial wildlife were also expressed for aquatic wildlife. The greatest concern involved possible adverse effects to fish (native and anadromous), either through direct exposure to insecticides or through reductions of aquatic insect food supplies. The safety of human consumption of fish from oversprayed streams was also a concern. Many people believe stream buffers are the only measures used to protect aquatic resources. The need for monitoring direct and secondary effects was emphasized.

Scenic Values/Recreation Use

The potential impact of spruce budworm damage on scenic viewscapes is a concern to many people. A reduction in recreational use (campgrounds, picnic areas, fishing, hiking, etc.) due to spruce budworm infestations is an Issue, as are the economic implications of these reductions.

Economics

Nearly all members of the public want to know if their money is being spent wisely. Most have suggested that the benefits and costs of Alternatives being considered should be displayed and compared. Opinions have been expressed regarding factors that should enter into the economic efficiency analysis and the appropriateness of assumptions used in past analyses. Benefits and costs associated with the following factors have been suggested for consideration: timber growth loss, effectiveness of *B.t.* compared to carbaryl, risk of budworm population resurgence or reinvasion, and reduced recreation use.

Concerns have been expressed for the possible economic effects on private landowners if a "No Action" decision were made. Where private land is adjacent to designated Wilderness, for instance; will policy not allow for treatment of infestations?

Concern has been expressed for possible reductions in National Forest timber harvest levels because of the budworm outbreak, and subsequent effects on employment and community stability.

Human Health

Most people who have expressed concern with budworm control projects want an understanding of possible hazards associated with the use of the insecticides being considered. The potential for long-term, short-term, and cumulative effects on human health is a concern. Possible effects on pregnant women, children, older people, and chemically sensitive people have been mentioned.

Most people believe high priority should be placed on preventing accidents and spills, and that if mishaps occur, the response should be swift and appropriate. Timely public notification should be given so people can avoid treatment areas. Emphasis on safety should be given throughout contract preparation, contract administration, and all operational aspects of a spray project.

Many of the people showing an interest in budworm control programs expressed a preference for continued biological rather than chemical insecticides. There are concerns about cumulative health risks from existing chemical use in the environment, and that additional chemical pesticide applications will add to human health hazards.

Effectiveness of Treatment Methods

The effectiveness of insecticides is dependent upon application techniques and proper timing. The efficacy of a biological insecticide is more dependent upon weather conditions than chemical insecticides. Unlike chemical insecticides, biological insecticides must be ingested by western spruce budworm larvae to be effective. Treating too early can result in many individual larvae escaping exposure to *B.t.* Because they are not feeding on foliage that is exposed to the spray of *B.t.*, the effectiveness can be diminished by exposure to sunlight before being ingested by larvae. Treatment administered too late might result in avoidance of *B.t.* by larvae that have advanced into the late sixth instar and have ceased feeding prior to pupation.

Timeliness of Treatments

Throughout its range, detectable populations of the western spruce budworm appear to persist indefinitely in stands that contain a substantial proportion of suitable hosts. Some people felt that immediate suppression action could limit the spread of an infestation and prevent a widespread outbreak.

Planning Questions

Analysis of public responses shows that many of the issues and concerns were interrelated to some degree. Those most closely interrelated have been grouped into eight planning questions.

1. What are the hydrologic effects of treatment/nontreatment?

Concerns have been raised regarding the effects of the western spruce budworm infestation upon water quality and quantity. Some feel defoliation and tree mortality influence snowpack levels, seasonal snowmelt, stream temperatures, turbidity, overland flows, and increased sediment associated with salvage of mortality is also a concern.

2. What is the effect of budworm treatment or nontreatment on the potential for wildfire?

As needles, branches and entire trees drop to the forest floor, fuel loading increases. What is the likelihood and potential impact of an uncontrolled fire event under the various management options?

3. What are the effects of each alternative on fish, wildlife, and domestic animals?

Concerns that increased human disturbance associated with suppression projects upon deer and elk during fawning and calving have been raised. Some people feel that fawns and calves would be more vulnerable to predation because of increased chances of desertion by the mothers. Bald eagle nesting territories occur within infested forests. There are concerns about the health effects on wildlife resulting from use of *B.t.* or carbaryl.

4. What is the effect of budworm treatment or nontreatment on scenic values and recreation use?

Timber stands affected by the current spruce budworm outbreak will suffer various types and degrees of damage to visual quality of forest landscapes. Treatment would avert most of the future predicted loss due to the current outbreak.

5. What are the economic implications of potential alternatives?

The potential losses in timber growth and yield due to foliage loss are of concern. Visual resources are also affected by spruce budworm as foliage becomes red or trees die. This may have an effect on the local economies of small communities dependent, in part, upon recreation income. Suppression projects bring dollars to the local economy by creating employment opportunities for local citizens and purchasing goods and services.

6. What are the effects on human health associated with treatment using insecticides?

It is recognized that some segments of the public have concerns about pesticide use. It is perceived that these insecticides either pose an immediate hazard to human health, or have the capacity to cause health problems in the future.

7. How effective are available treatment methods in reducing the insect population? (Efficacy)

The efficacy of *B.t.* and other pesticides is directly related to the method of application, weather, and timing. High quality *B.t.* applications, as well as high quality carbaryl applications, are likely to suppress budworm populations below an average of 1 larva per branch tip.

8. What is the timeliness of treatment for this and future outbreak cycles?

Concerns have been raised about the time lapse between the discovery of the outbreak and the start of treatment. What is the most effective timing of treatment? Can early treatment stop widespread infestation?

Alternatives, Including the Proposed Action

This Environmental Impact Statement (EIS) considers four different ways of managing western spruce budworm populations and a "No Action" Alternative.

Alternative A (No Action)

This Alternative allows no intervention in the western spruce budworm infestation cycle. The epidemic would run a course subject only to natural, unpredictable controls. Western spruce budworm activity would be monitored annually. An aerial "sketchmap" survey would determine the extent of visible defoliation. The No Action Alternative forms a baseline against which all other Alternatives are compared.

Alternative B

This Alternative provides for a direct suppression strategy using the biological insecticide *B.t.* only. Suppression projects would be designed to protect those timber, recreation, and visual resources which are expected to sustain unacceptable damage. Treatment would involve the aerial application of *B.t.* to selected areas.

Alternative C

This Alternative prescribes a direct suppression strategy which requires application of the chemical insecticide 'carbaryl'. At this time, carbaryl is recognized as the most effective chemical insecticide available for suppressing budworm populations. It is registered with the Environmental Protection Agency (EPA) as safe for forest application.

Application of carbaryl would involve aerial "broadcast" treatment of infested areas. A strip of untreated vegetation would always be left adjacent to streams and around other bodies of water when this chemical is used.

Alternative D

This Alternative provides for the use of either *B.t.* or carbaryl. Alternative D proposes suppression projects which would protect resources at risk of unacceptable damage. *B.t.* application would be allowed adjacent to but not over streams and other bodies of water. Treatment with carbaryl would be allowed over treatment areas in special instances, but untreated buffer zones would be maintained around streams and other bodies of water. Whether carbaryl or *B.t.* is used in a treatment area would be determined on a site specific basis. The proximity of human habitation or

the frequency of human use in proposed treatment areas will be considered in every decision.

Alternative E (Preferred)

This Alternative was developed in consideration of public comments and concerns which addressed the Draft EIS. It is largely a composite of elements described in Alternatives B and D. This Alternative provides for direct suppression of budworm infestations. The biological insecticide *B.t.* is defined as the treatment of choice. However, carbaryl may be used in the event that *B.t.* is unavailable or is expected to be ineffective in site-specific instances. Situations in which the use of carbaryl might be warranted are:

- When *B.t* is not available.
- Where the proven effectiveness of carbaryl is shown to be substantially better than prescribed solutions of *B.t.*
- When high value stands are infested by rapidly expanding western spruce budworm populations and effective insect control requires an insecticide that has both contact and residual properties.
- In research and pilot test projects designed to evaluate unproven formulations or lower dosages.
- When a Regional Entomologist's analysis recommends its use.

The decision to use *B.t.* or carbaryl within treatment areas will be made in project-specific environmental analysis. The resources and environment within each area will be considered in the decision making process. Human habitation and the frequency of use within the analysis areas will be given primary consideration. Formulations of *B.t.* could be adjacent to but not over streams or other bodies of water. Treatment with carbaryl would require that an untreated buffer strip be maintained along streams or around other bodies of water.

A comparison of these Alternatives follows:

Comparison Of Alternatives

Planning Question #1:

What are the hydrological effects of treatment and nontreatment?

Alt. A. (No Action)	No significant increase in annual streamflow or peak discharge is anticipated as a direct result of defoliation and mortality. Cumulative effects of extensive management activities, combined with defoliation, could produce significant increases in annual streamflow. These increases could degrade water quality. Defoliation and mortality could promote slight increases in water temperature in some stream segments.
Alt. B. (Use of *B.t.* only)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.
Alt. C. (Use of Carbaryl only)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.
Alt. D. (Use of *B.t.* and/or Carbaryl)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.
Alt. E. (*B.t.* as primary insecticide)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.

Planning Question #2:

What are the effects of Alternatives on fuels and fire?

Alt. A. (No Action)	A minimum impact on fuel loading in areas where only scattered mortality has occurred; severe defoliation and high levels of mortality will result in significant increases to fuel loading; fire intensity is expected to be high in continuous areas of mortality; fire line construction wil be slowed by heavier fuels.
Alt. B. (Use of *B.t.* only)	Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.
Alt. C. (Use of Carbaryl only)	Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.

Alt. E.
(*B.t.* as primary insecticide)

Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.

Planning Question #3:

What are the effects of Alternatives on fish, wildlife, and domestic animals?

Alt. A.
(No Action)

Implementation of this Alternative would result in no adverse impacts to fish or animals.

Alt. B.
(Use of *B.t.* only)

Implementation of this Alternative would result in no significant impacts on fish or animals. Some resources may benefit slightly.

Alt. C.
(Use of Carbaryl only)

Implementation of this Alternative may result in significant impacts to some resources. Specifically, some species of small mammals, birds, and insects may be adversely affected by the toxicological properties of carbaryl or it's carriers, diesel oil and kerosene.

Alt. D.
(Use of *B.t.* and/or Carbaryl)

Implementation of this Alternative, in compliance with prescribed mitigation measures, may result in minor impacts to some resources. Significant impacts would probably be mitigated by the use of *B.t.* in sensitive ecosystems.

Alt. E.
(*B.t.* as primary insecticide)

Under ordinary circumstances implementation of this Alternative would not result in significant impacts to other resources. Some resources may benefit slightly. Implementation with carbaryl, in compliance with established mitigation measures, may result in minor impacts to some resources. Significant impacts would probably be mitigated by the use of *B.t.* in sensitive ecosystems.

Planning Question #4:

What effects would implementation of the Alternatives have on viewsheds and recreational use?

Alt. A.
(No Action)

Severe defoliation will result in color and texture changes for a decade or more; changes in visual quality could result in decreased recreational use, with a corresponding impact on the recreation economy.

Alt. B.
(Use of *B.t.* only)

Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.

Alt. C.
(Use of Carbaryl only)

Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.

Alt. D. (Use of *B.t.* and/or Carbaryl)	Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.
Alt. E. (*B.t.* as primary insecticide)	Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.

Planning Question #5:

What are the economic implications of the Alternatives?

Alt. A. (No Action)	Long-term reduction in future supply of wood fiber; short-term increase of logs for manufacturing due to salvage operations.
Alt. B. (Use of *B.t.* only)	Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.
Alt. C. (Use of Carbaryl only)	Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.
Alt. E. (*B.t.* as primary insecticide)	Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.

Planning Question #6:

What are the effects on human health associated with treatments using B.t. and other chemicals?

Alt. A. (No Action)	This Alternative would have no effect on human health, since the Alternative prescribes no chemical or biological insecticides.
Alt. B. (Use of *B.t.* only)	This Alternative presents the least risk of the direct suppression Alternatives. The use of *B.t.* poses little risk of acute or chronic effects on human health.
Alt. C. (Use of Carbaryl only)	This Alternative presents the highest risk to human health of any direct suppression Alternative being considered. Carbaryl poses a human health risk only in the event of accident. The petroleum-distillate carrying agents (kerosene and diesel oil), commonly used for application, present a risk under routine worst-case conditions and in the event of accidents.
Alt. D. (Use of *B.t.* and/or Carbaryl)	This Alternative presents human health risks less that Alternative C, but greater than Alternative B. The level of risk would be reduced in proportion to the extent that *B.t.* is used instead of carbaryl.

Alt. E. (*B.t.* as primary insecticide)	This Alternative would generally present minimum risk to human health. The use of *B.t.* poses little risk of acute or chronic effects on human health. Risk to human health would be reduced to the extent that *B.t.* is applied in place of carbaryl.

Planning Question #7:

How effective are the treatment methods?

Alt. A. (No Action)	No effect on achieving lasting budworm population reductions.
Alt. B. (Use of *B.t.* only)	Applications are likely to suppress budworm populations to below identified threshold levels; populations unlikely to develop a tolerance; resurgence and reinvasion are not anticipated.
Alt. C. (Use of Carbaryl only)	Applications are likely to suppress budworm populations to below identified thresholds; budworm populations can develop a tolerance to carbaryl applications; budworm reinvasion from buffers and other adjacent untreated areas is possible; inadvertent sublethal doses can stimulate resurgence of populations.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Flexibility to use either *B.t.* or carbaryl as the situation warrants, is likely to suppress budworm populations to below identified threshold levels; use of carbaryl has potential to influence occurrence of reinvasion and/or resurgence.
Alt. E. (*B.t.* as primary insecticide)	Flexibility to use either *B.t.* or carbaryl as the situation warrants, is likely to suppress budworm populations to below identified threshold levels; use of carbaryl has potential to influence occurrence of reinvasion and/or resurgence.

Planning Question #8:

What is the timeliness of treatment for this and future outbreak cycles?

Alt. A. (No Action)	Implementation of this Alternative would allow budworm infestations to follow a natural course. It would have no effect on the frequency of future epidemics.
Alt. B. (Use of *B.t.* only)	Implementation of treatments prescribed in this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. Earlier treatment would not have prevented the "spread" of budworm infestation. The application of *B.t.* should have no effect on future outbreaks.
Alt. C. (Use of Carbaryl only)	Implementation of treatments prescribed in this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. The application of carbaryl (with buffers where appropriate) may have an effect on the ability of budworm populations to reinvade and resurge, thus affecting future outbreaks.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Implementation of treatments prescribed in this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of vigorous populations.

Alt. E. (B.t. as primary insecticide)	Implementation of treatments prescribedin this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. Earlier treatment would not have prevented the "spread" of budworm infestation. The application of *B.t.* should have no effect on future outbreaks. The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of vigorous populations.

Environmental Consequences

Environmental consequences result when changes are made to ecosystems; changes which may be brought about either by commission or omission. Under each of the action Alternatives, western spruce budworm populations would be managed using either a biological or a chemical insecticide, or a combination of both.

The EIS prescribes that a project-specific environmental analysis will be conducted for each proposed budworm management project. The appropriate disclosure document will be prepared for each year's proposed treatment(s) and made available for public review. This analysis tool would consider individual projects, and would involve the public in the decision making process. If the No Action Alternative is selected, monitoring of the current budworm epidemic will continue.

The following section summarizes the most significant environmental impacts projected to result from implementation of each of the alternatives. A complete analysis of the effects can be found in chapter IV and appendix F of the Final Environmental Impact Statement.

Water Quality/Quantity

Alternative A - No Action

Alternative A, the No Action Alternative, would result in few significant impacts to water quality and quantity. In watersheds where there are extensive, ongoing management activities, the cumulative impacts of these activities and budworm defoliation could produce a significant increase in annual streamflow.

Alternatives B, C, D and E

Implementation of Alternatives B, C, D and E would reduce defoliation and eliminate the slight impacts described under the No Action Alternative. Reduced defoliation would also lessen the cumulative impacts described under Alternative A.

Plant Communities

Alternative A - No Action

Over time, the No Action Alternative would allow mortality which would open pockets in the canopy. The cumulative effect of this Alternative would be a gradual change of stand composition.

Alternatives B, C, D and E.

The action Alternatives would tend to keep timber stands and attendant plant communities in their present successional state.

Timber

Timber stands affected by the current spruce budworm outbreak have sustained various types and degrees of loss in wood fiber production. Diminished wood fiber production is primarily a result of radial growth loss. Additional reductions are due to top-kill, tree deformity, and tree mortality. Reduced seed production may also be attributed to spruce budworm damage.

Alternative A - No Action

The maximum amount of budworm-caused radial growth loss would continue until natural regulating factors caused a population collapse. In the long term, as the host trees are replaced by more resistant species, growth loss due to the infestation would become less. The amount of tree mortality will vary with the intensity and degree of infestation. Scattered mortality may be beneficial in some instances. Local woodcutters, for example, may enjoy short-term gains from the salvage of dead trees. In some stands, mortality of budworm host trees may actually accelerate the growth of non-host species.

The maximum amount of top-kill and deformity caused by a full-term budworm outbreak would be experienced. Western spruce budworm infestations have been shown to cause damage to the cones of Douglas-fir, grand fir, and western larch. Under this Alternative, reduced seed production would continue until epidemic populations of spruce budworm collapse naturally. As a direct result, natural regeneration of the host species would be reduced.

Alternatives B, C, D and E.

Projections show that implementation of these Alternatives would result in a level of budworm population control that would avert most additional loss of wood fiber production caused by the current outbreak. Under any of the action Alternatives, mortality would not be expected in treated stands which have sustained no previous damage.

Under these Alternatives, the top-kill and tree deformity described in Alternative A would be averted to some degree. Those trees which have not already sustained top-kill could be successfully treated. Application of *B.t.* and/or carbaryl to infested areas could avert much of the budworm-caused seed damage. Seed production would therefore be greater

than under the No Action Alternative. The chances of establishing stands through natural regeneration would be improved.

Fire and Fuels

Alternative A - No Action

The No Action Alternative would have little effect on fuel loading in areas where only scattered mortality has occurred. However, the extensive defoliation which results in increased mortality would cause a significant rise in fuel loading.

Alternatives B, C, D, and E

Alternatives B, C, D and E would reduce or eliminate the short-term potential for fuel buildup. Only scattered mortality would be expected.

Western Spruce Budworm

Alternative A - No Action

Implementation of the No Action Alternative would not result in lasting reductions in budworm populations. If the No Action Alternative were selected, the outbreak would be allowed to run a natural course of rise, peak, and decline. Weather, parasites and predators, disease, and food supply would be allowed to exert their normal influence over the outbreak populations. Implementation of this Alternative would not preclude the long-range prevention of budworm outbreaks through current and future forest management practices.

Alternative B

Applying *B.t.* is not considered likely to prolong the outbreak. Application should have no effect on natural enemies. When populations of budworm are suppressed, the natural enemies should be able to again exert their controls.

Resurgence is expected to be less of a problem under this Alternative than under Alternatives C and D, because *B.t.* would not stimulate vigorous population growth if areas receive sublethal doses.

It is unlikely that budworm populations would develop a tolerance to *B.t.* applications. Quality *B.t.* applications would be likely to suppress budworm populations to below the established threshold density of 1 larva per branch tip.

Alternative C

Applying carbaryl would not likely prolong the outbreak, and would have only minor effects on the budworm's natural enemies.

Resurgence is a potential problem with the use of carbaryl. Studies show budworm populations can develop a tolerance to carbaryl applications. Quality carbaryl applications would be likely to suppress budworm populations below the established threshold density of 1 larva per branch tip.

Alternative D

The option of using either *B.t* or carbaryl would allow managers to select the one which best meets the needs of a particular situation. When there is no practical difference, or no concern about potential effects, the choice could be made for economic or other reasons.

Alternative E

Implementation of this Alternative would result in effects similar to those described under Alternative B. The primary difference between these two Alternatives is that under Alternative E carbaryl could be used, but only in very limited instances.

Wildlife

Alternative A - No Action

Taking no action, and allowing continued spruce budworm infestation, will result in minor reductions of hiding and thermal cover for big game. Offsetting these losses will be an increase of forage production associated with reduced tree crown cover. Both effects are expected to be of little consequence.

Alternative B

Since *B.t.* is not a broad-spectrum insecticide and affects only lepidopterans (moths and butterflies), expected impacts upon terrestrial organisms are slight. Some nontarget moth and butterfly species, which are in the larval stage at the time of treatment, may be at risk of experiencing population reductions for a year or two.

Implementation of Alternative B would result in minimal disturbance of wildlife populations, and would have little adverse impact to survival and abandonment of young.

Alternative C

No realistic doses of carbaryl exceed the EPA risk criterion of 1/5 LD_{50}. Alternative C would not present a substantial risk to wildlife populations.

Wildlife exposures are far below the EPA risk levels for diesel oil and kerosene and, under this program, there would be no risk to wildlife populations from their use.

Alternative D

It is assumed *B.t.* will be applied on sensitive areas, e.g., riparian/watershed, and carbaryl will be used on all other areas. The most substantial difference between this alternative and the carbaryl-only alternative is the reduced impact on the aquatic ecosystem.

Alternative E

The biological insecticide *B.t.* is the treatment of choice. Wildlife impacts should be minor, essentially the same as for Alternative B. If use of carbaryl is warranted, the effects on wildlife would be similar to those expected under Alternative D.

Threatened, Endangered, and Sensitive Species

Alternative A - No Action

This Alternative would have no known negative impact to threatened, endangered or sensitive species.

Alternative B

This Alternative has potential to impact threatened, endangered, and sensitive plant and animal species in a limited manner. The potential for direct impact would probably result from mechanical activities associated with aerial application. Negative impacts are not expected to be substantial.

Alternative C

Under this Alternative (the use of carbaryl only) the potential effects on threatened, endangered, and sensitive species are greater than those expected under the other action Alternatives. However, negative impacts on these species is not expected to be substantial.

Alternative D and E

The effect on threatened, endangered, and sensitive species would be similar to that described for *B.t.* Potential for direct impact would be greatest from mechanical activities associated with the aerial application of insecticide. Negative impacts are not expected to be substantial.

Fisheries/Aquatic Ecosystem

Alternative A - No Action

Most data indicate that even with heavy infestations of spruce budworm, most tree defoliation would be less than 100 percent, while stem mortality over the outbreak area would be less than 3 percent. Given these values, it is unlikely that water temperatures of streams in affected areas will be significantly altered.

The No-action Alternative, having minimal adverse impacts on water quality, would have similar minimal effects on fisheries. Aquatic invertebrates would not be affected by the No-action Alternative. This alternative would have the least impact or risk of impact upon aquatic invertebrates and fish.

Alternative B

Few toxic effects have been reported in studies of aquatic species exposed to *B.t.*

B.t. treatments in streamsides would pose no threat to aquatic organisms unless a direct spill occurred. Concentrations in streams resulting from normal treatment would be far below the levels that proved toxic to blackfly and mosquito larvae. The adverse effects of spills would be short-term and limited to relatively small stream reaches.

The risk of spills, and subsequent contamination of water with fuel and/or large quantities of *B.t.*, is very low.

Alternative C

In most cases, carbaryl poses low risk to fish in ponds or streams when a 500 foot buffer strip is maintained. If the body of water is very shallow (6 inches or less in depth), there may be moderate risks to some trout species. Aquatic invertebrates, such as water fleas, stoneflies, and scuds, are at significant risk if the estimated environmental concentrations calculated in this analysis are present for anything but a transient time period, as would be the case in shallow ponds or very slow-moving streams.

Diesel Oil and Kerosene would pose significant risks to all representative aquatic species if the concentrations calculated in this risk assessment were not transient.

Alternative D

The impact on fisheries and aquatic systems is expected to be somewhat less than effects from Alternative C.

Alternative E

The impacts on fisheries and aquatic systems is expected to be similar to Alternative B in most cases. If carbaryl is used, the impacts expected to the aquatic system would be somewhat less than expected for Alternative D.

Visual Resources

Alternative A - No Action

The impact of continued defoliation on visual quality and the Forest users' experience will be greatest in the areas where severe defoliation is found. The cumulative effect of the No Action Alternative would be an increase in the acres of defoliation and visual change that occur each year; changes which would continue until budworm populations are reduced by natural events.

Alternatives B, C, D and E

Short-term protection of foliage by using *B.t.* or carbaryl reduces the changes in color and texture that occur on the landscape, but does not eliminate them. The cumulative effect of implementing Alternatives B, C, D or E would be an annual reduction in acres severely defoliated.

Human Health

A risk assessment was done to assess the risks to human health of using the chemical insecticide, carbaryl and the biological control agent, *Bacillus thuringiensis (B.t.)* for controlling western spruce budworm in Region 6.

The risk assessment also addressed the human health risks of a number of chemicals associated with the application of the insecticides and *B.t.* Because carbaryl is commercially formulated (as Sevin 4-Oil) with kerosene, and because diesel oil is used as a carrier in the application of Sevin 4-Oil, the risks of these two petroleum distillates were analyzed.

In essence, the risk assessment estimated doses people may get from applying the insecticides (worker doses) or from being near an application site (public doses), then compared those estimated doses with doses shown to cause no observed effects in tests on laboratory animals. The risk assessment employed three principal analytical elements: hazard analysis, exposure analysis, and risk analysis.

The hazard analysis identified the toxic properties of *B.t.*, and of each chemical insecticide originally considered for the program, in a thorough review of available toxicological studies.

The exposure analysis analyzed a range of possible exposures--from realistic to extreme--using three types of scenarios:

Typical application scenarios (routine-typical) to estimate worker and public doses that may reasonably be expected to occur during routine operations.

Worst-case application scenarios (routine worst-case) to give very high dose estimates not likely to be exceeded except in the case of an accident.

Accident scenarios to estimate public and worker doses from exposure to spray mix or concentrate, directly or in spills into drinking water.

Risk analysis evaluated the risk of acute and chronic health effects by comparing estimated doses to no-observed-effect-levels (NOEL's) in laboratory animal studies, using a margin of safety (MOS). The MOS is calculated by dividing the NOEL by the estimated dose. A benchmark risk MOS of 100 was used to assess the likelihood of effects. Doses that are 100 times lower than the laboratory NOEL are assumed to present a low risk of human health effects. Risk increases as the estimated dose approaches the laboratory toxicity level; that is, as the MOS decreases.

There were a number of data gaps and areas of uncertainty identified in the risk assessment. In each of those areas, a conservative approach was used or a worst-case analysis was done that tended to increase the estimates of risk to err on the side of safety.

Hazard Analysis Results

This section summarizes the toxic properties of carbaryl, diesel oil, kerosene, and *Bacillus thuringiensis*.

Reproductive/Developmental Toxicity: Carbaryl is teratogenic in many test species, with lowest NOELs found in dogs, but again, the dog effects are not assumed to extrapolate to humans. An inhalation teratology study in which rats were exposed to diesel fuel on days 6 through 15 of gestation did not result in any significant teratogenic effects. The kerosene reproductive NOEL of 751 mg/kg/day is based on the diesel oil reproductive NOEL because no reproductive data exist for kerosene and it is similar in composition to diesel oil. The literature contains no data about the reproductive or teratogenic effects of *B.t.*

Carcinogenicity: The review of 10 chronic toxicity studies, and the absence of significant tumor incidence at 400 ppm in rats and mice, has provided sufficient evidence for EPA to conclude "that carbaryl is not oncogenic in experimental animals". The cancer potency of diesel oil is based on two carcinogenic constituents, benzo-a-pyrene (BaP) and benzene, known to be present in low concentrations in diesel and fuel oils. The carcinogenic potential of kerosene is similar to that of diesel oil since the same substances (BaP and benezene) are responsible in both cases. Kerosene's carcinogenicity is assumed to be the same as that of diesel oil. The literature contains no data about the carcinogenic potential of *B.t.*

Mutagenicity: EPA has concluded that carbaryl does not pose a mutagenic risk because only weak mutagenic responses have been measured and there is no evidence demonstrating the ability of carbaryl to reach germinal tissue; hence, germ cells should not be affected. Diesel oil is considered mutagenic in this risk assessment because of the presence of polycyclic aromatic hydrocarbons (PAHs) that are known or suspected mutagens. Because kerosene contains polycyclic aromatic hydrocarbons (PAH's), as diesel oil does, it is assumed to present a mutagenic risk in this risk assessment. All test materials for *Bacillus thuringiensis* were negative in all systems.

Exposure Analysis Results

Margins of safety (MOS') were computed for workers and the public for routine operations (typical and worst-case exposures), and for accidents, for carbaryl, diesel oil, kerosene, the combined petroleum distillates, and for *B.t.* The margins of safety were computed by dividing the laboratory-determined NOEL's by the doses listed in the risk assessment.

Risk to the Public

Margins of safety for the public in routine-typical spraying are greater than 100 for systemic effects for the three chemicals, for the combined petroleum distillates, and for *B.t.* Margins of safety for reproductive effects for the three chemicals also are all greater than 100. These large margins of safety mean that members of the public could be repeatedly exposed to these levels and suffer no adverse effects.

These results indicate that no systemic or reproductive effects are likely to result from the use of carbaryl or *B.t.* in spruce budworm suppression operations.

The routine worst-case scenarios were intended to indicate the upper bounds for public exposure to insecticide applications in the Pacific Northwest. The low probability of occurrence of each assumed event must be emphasized. It is extremely unlikely that anyone would receive a dose as high as those estimated here.

MOS's for reproductive effects are greater than 100 for diesel oil, kerosene and *B.t.* for the routine worst-case exposures. MOS's for diesel oil and the combined petroleum distillates are greater than 100 except for dermal and inhalation exposure to drift. These results indicate there is some slight risk of effects from carbaryl drift and from diesel oil/petroleum distillate drift exposure.

The extent of effects would depend upon an individual's duration of exposure and any precautionary measures that were taken. For example, if people gathered a bushel of berries from a spray area, did not wash them but froze them, and then ate them every day for a month, they might experience ill effects such as nausea and dizziness. However, if people bathed after being in the forest or washed food items before eating them, the doses would drop and substantially increase the margins of safety.

Risk to Workers

From Routine Operations: In the routine-typical exposures, all categories of workers, except backpack applicators, applying carbaryl, kerosene, and *B.t.* have MOS's greater than 100.

Carbaryl, diesel oil, and the combined petroleum distillates have MOS' less than 100 for routine worst-case exposure. The probability of workers receiving repeated daily doses as high as predicted here is extremely low. Therefore, even if a worker felt ill for a day or so from an unusually high dose, permanent damage would be unlikely.

Risk Analysis Results

A worst-case analysis for cancer was conducted for carbaryl, diesel oil, kerosene, and the petroleum mixture. There are no data on *B.t.* carcinogenicity, so no quantitative cancer risk assessment could be performed for this material.

Cancer Risks

Results for carbaryl, diesel oil, kerosene, and petroleum distillates indicate that no member of the public is at a greater than 2.3 in 100 million risk of cancer from routine exposures.

Workers are not at cancer risk greater than 1 in 1 million for any task or chemical. Cancer risks for worker accidents also do not exceed 1 in 1 million for any chemical.

Risk of Effects from *B.t.* Contaminants (Bioburden)

Humans exposed to *B.t.* in spruce budworm suppression operations may be at some low level of risk from eye or skin irritation or infection, but are not at risk of any systemic effects from *B.t.*

Carbaryl was nonmutagenic in the majority of assays conducted and was nononcogenic in all of the carcinogenicity tests performed; therefore, it can be assumed that its germ cell mutagenic risk is slight to negligible. Kerosene and diesel oil both contain PAH's and are considered to be possibly mutagenic.

Cumulative Effects

No individual member of the public is likely to receive repeated exposures to any of the insecticides because of the remoteness of most treatment units, the widely spaced timing of repeated treatments, and the use of a variety of insecticides for different purposes.

Summary Of Human Health Effects Of The Alternatives

Alternative A - No Action

This alternative would have no effect on human health because no chemical insecticides or biological controls would be used.

Alternative B

This alternative presents the lowest risk of all the alternatives except the No-action Alternative.

Alternative C

Carbaryl poses a human health risk only in the case of accidents. The petroleum distillates, kerosene and diesel oil, associated with carbaryl application do present a risk under routine worst-case conditions and in accidents. Therefore, this alternative presents the highest risk to human health of the five alternatives. The petroleum distillates present a degree of uncertainty in the risk evaluation because of lack of data on their toxicity. Should additional data become available, their risks would be reassessed.

Alternatives D and E

Human health risks of this alternative would be less than alternative C, but greater than alternative B. The level of risk would be proportionate to the ratio of *B.t.* and carbaryl used. Risks would be reduced to the extent that *B.t.* is used instead of carbaryl.

Economic Efficiency And Local Impacts

Alternative A - No Action

Under the No Action Alternative, a long-term reduction in the future supply of fiber is projected for most analysis units.

Alternatives B, C, D and E

To the extent funding is available, investment in direct suppression with *B.t.* or carbaryl would be made in analysis units which offer the greatest net financial and intangible benefits.

Social Factors

The effects of implementation of any Alternative on consumers, citizens' civil rights, minority groups, and women are estimated to be insignificant. Generally, these effects are related to the supply of wood fiber and the resulting cost of wood products. Primary and secondary employment associated with the manufacture of wood products is also a consideration.

Irreversible Or Irretrievable Effects

No irreversible commitments of resources have been identified. Implementation of the Preferred Alternative would avert most of the total net timber loss which could occur from not treating the infestation. Recouping all of the estimated loss could be accomplished only with a highly successful treatment program which treated all of the infected stands.

Chapter 1: Purpose and Need

Eggs

CHAPTER I. PURPOSE OF AND NEED FOR ACTION

Introduction

Large portions of the National Forests in Oregon and Washington are actively managed to produce timber, recreational opportunities, forage, water, and wildlife habitat. An integral part of management is protection of resources from destructive agents, including insects, disease, fire, flood, and drought.

Insects play various roles in the ecological systems of National Forests, creating both beneficial and detrimental effects on Forest resources. Insects are an important part of the ecological system and understanding their role is key to effective management of forests.

Current Situation

Various plant communities on both sides of the Cascade Range have been experiencing an ongoing infestation of western spruce budworm. Douglas-fir, grand fir, white fir, Engelmann spruce, subalpine fir, and western larch are the primary sources of food for western spruce budworm. The spruce budworm is capable of consuming and destroying much of the new foliage on these trees. The result is vast areas of brown or defoliated trees, some of which could eventually die. Although western spruce budworm is always present in the forest, large budworm population increases are now evident throughout the Region. The associated damage has caused considerable concern to forest landowners and National Forest users. Defoliation may affect the human environment in several ways:

- Reduction of the economic value of forests due to loss of tree growth.
- Decline in forest visual resource values.
- Decrease in future supplies of goods and services in affected areas.

The current western spruce budworm epidemic now encompasses a cumulative area of approximately 7 million acres. Of those acres, roughly 2.5 million were first affected in 1988. According to the 1988 pheromone trapping survey, the intensity of this outbreak is declining in many areas. Efforts to control current infestations could have important consequences on the social, biological, and physical environments.

Chapter II of this Environmental Impact Statement (EIS) describes five Alternatives for managing current western spruce budworm infestations on National Forest land in eastern Oregon and Washington. These Alternatives are:

A. No action

B. Suppression, using *B.t.* only (biological insecticide)

C. Suppression, using Carbaryl only (chemical insecticide)

D. Suppression, using *B.t.* and/or Carbaryl

E. Suppression, using *B.t.* as the primary treatment option, allowing for use of Carbaryl only under extraordinary circumstances

Description Of The Insect

The western spruce budworm, (*Choristoneura occidentalis Freeman*), is the most widely distributed defoliator and potentially destructive insect of coniferous forests in western North America (Fellin and Dewey, 1982). The adult is a small orange-brown mottled moth. The destructive feeding period though, is during the caterpillar (larval) stage of the insect. Native to most fir stands, the insect's population levels are usually held in check by the interaction of parasites, predators, timber stand conditions, and weather. Periodically, the complex of natural controls no longer limits growth of budworm numbers and epidemic infestations occur.

At epidemic levels, budworms may defoliate entire timber stands, feeding primarily upon new needle growth and affecting mostly Douglas-fir, grand fir, and white fir, their preferred host species. Epidemics typically last from 6 to 10 years, and result in five

Western Spruce Budworm Defoliation 1988

Figure I-I

National Forests of the Pacific Northwest Region

types of damage to host trees: growth loss, top-kill, deformity, reduced seed production, and mortality.

The western spruce budworm is a native insect species. It is one of nearly a dozen species, subspecies, or forms of a spruce budworm 'complex' which is found throughout the western, north-central, and northeastern United States. Budworm is also found in several western and maritime Canadian provinces. The genus is also represented in Europe.

In Oregon and Washington the budworm completes one cycle of development from egg to adult each year. Following flight, in late July and August, the adult moths lay eggs that soon develop into tiny larvae. The larvae remain in an inactive state, under bark scales and among lichens on tree boles or limbs throughout the winter. In early May to late June the larvae emerge and begin their active feeding stage. As rapidly growing larvae, spruce budworms molt (shed their skin) a total of five times. The six intervening stages are called instars. After about 30 to 40 days, larvae develop into pupae. Moths emerge from the pupae after about 10 days and begin the cycle again.

Within its range the budworm can infest forests in a variety of ecological situations: in pure and mixed stands on both poor and good sites, over wide topographic, physiographic, climatic, geographic, and elevational gradients, and in a variety of wildlife habitat. In Oregon and Washington, the vegetation zones affected are the Douglas-fir and true fir zones (Franklin and Dyrness, 1973). These include the ponderosa pine/Douglas-fir co-climax and the mixed conifer, white fir, and subalpine fir plant communities (Hall, 1973). The budworm feeds on all age classes of host tree species.

The most common host tree species are Douglas-fir, grand fir, white fir, subalpine fir, Engelmann spruce, and western larch. Occasional host species include lodgepole pine and ponderosa pine. On most host tree species, western spruce budworm larvae feed as typical defoliators. Though they prefer succulent new foliage, they also feed on older foliage when new foliage is scarce or unavailable. By the time larvae reach maturity, in early to mid-July, they will often have consumed or destroyed much of the new foliage on host trees.

Western spruce budworm larvae also feed on the cones and seeds of several species of host trees, notably Douglas-fir (Dewey, 1970) and western larch (Fellin and Shearar, 1968).

Budworm populations are usually regulated by natural factors. When populations are low, parasites, predators, and adverse weather serve to limit population growth (Dewey, 1974). More than 40 species of parasites are known to attack the budworm in its larval stage, but none has been found to have much effect on epidemic populations (Torgersen et al., 1984). Starvation can also be an important mortality factor in regulating populations.

Some studies suggest that weather may produce the most dramatic effect on budworm populations. Small larvae may be blown from the host tree to the forest floor, where they might be eaten by predators or die from starvation or exposure to sunlight. Cool summer weather retards feeding and development, increasing the time larvae are vulnerable to predators and parasites. Occasionally, larvae will not have emerged from eggs before the first freezing temperatures of late summer and early fall. Significant population reduction may also result from exceptionally warm autumn weather. Under this condition the larvae remain active too long and deplete the reserves of nutrients they carry from the egg. Without these reserves a majority of the larvae will starve during the winter and early spring before the infestation can do serious damage to host plants. Conversely, it is also believed that favorable weather, such as late onset of fall freezing and warm spring and summer conditions, is a major contributor to population increases.

In some forested areas the individual or combined effects of natural factors is probably responsible for the decline, termination, or movement of western spruce budworm infestations. However, the absence or ineffectiveness of natural mortality factors may also result in population resurgences. Because the ecosystems of Oregon and Washington provide a variety of ideal budworm habitat, the combined effect of natural mortality factors in one area may only serve to move populations to areas where climatic and forest stand conditions are more favorable.

Scope Of The Decision

The scope of considerations described in this EIS will provide the responsible official with a basis for deciding which strategy, if any, should be used to manage the current epidemic of budworm infestation.

During the public involvement process, concern was expressed as to what could be done to reduce damaging infestations long term. These solutions consist of silviculture manipulation of a stands composition to reduce the amount of host species present. Generally, the USDA Forest Service is in agreement with the use of these means. However, the spruce budworm is only one of many insects and diseases to be considered in management strategies for

dealing with the future health of forests. Complex interactions of forest insects and diseases exist in all forest plant communities. A management strategy for control of one insect or disease may increase or decrease the effects of other insects and diseases. It may also effect the needs or outputs of other forest resources.

The Forest Service does not presently have the computer modeling capability to make long-term strategic decisions for management of the insects and disease complex. In addition, techniques do not exist to integrate these decisions with resource allocation decision that are made during development of the Forest Plans. The Forest Service is committed to have this capability within the foreseeable future.

In addition, silviculture solutions will take decades to implement and thus, be ineffective towards the present infestation. Since the scope of this EIS is limited to treatment of the current infestation, long term silviculture treatments were precluded from consideration.

The decision which is reached from consideration of this FEIS will be applied to areas throughout the Pacific Northwest Region, where direct suppression of western spruce budworm infestations appears to be warranted. Site specific analyses will be conducted within individual management units, to consider the possible effects of proposed treatments. Environmental analysis will be conducted and the appropriate disclosure documents prepared.

Decision Needed

During the investigation of possible actions and their predictable environmental effects, four Alternatives for managing epidemic budworm infestations on both public and private lands in the Region were developed. In direct response to public comment received from reviewers of the Draft EIS, a fifth Alternative was added. This Final Environmental Impact Statement (FEIS) displays the possible environmental impacts and management implications of all five Alternatives. In consideration of comments received from scientists, Government agencies, and the public, this FEIS has been prepared and issued, along with a Record of Decision signed by the Regional Forester.

History Of Western Spruce Budworm Control In Oregon And Washington

The presence of western spruce budworm was first recorded in the Pacific Northwest Region in 1914, when specimens were collected from Douglas-fir trees in Ashland, Oregon (Lindsten et al., 1949). Subsequently, budworm defoliation was noted in limited areas near Northport, Washington in 1928, in central Oregon near Mitchell in 1931, and in the Warner Mountains southeast of Lakeview, Oregon, in 1932, 1941, and 1942 (Lindsten et al., 1949; and Carolin, 1965). All of these infestations were small and subsided without causing appreciable damage to timber stands.

In 1943, budworm defoliation was discovered in the Methow Valley on the Okanogan National Forest in north-central Washington. This infestation eventually developed into the first major recorded western spruce budworm epidemic in the Pacific Northwest Region. An estimated 200,000 acres were defoliated before the infestation subsided in 1948. In 1944, an infestation developed on the Umatilla National Forest in northeastern Oregon that eventually involved the entire fir host type throughout the Blue Mountains.

In 1988, the need to take a broader look at the epidemic was recognized. A commitment was then made to develop the operational capability needed to prepare strategies for management of the complex of insects and disease.

A number of insecticides have been used since 1976. Recent evaluation has focused on the use of *Bacillus thuringiensis (B.t.)*, a microbial insecticide (Beckwith et al., 1984; and Ragenovich, 1985).

A summary of western spruce budworm suppression projects conducted in Oregon and Washington from 1949 through 1988 is shown in Table I-I, Dolph (1980); to provide greater detail about budworm activity and the suppression projects that occurred through 1979.

Since 1970, budworm activity has been concentrated in three areas of the Region: the east slope of the Washington Cascade Range, the east slope of the Oregon Cascade Range, and the Blue Mountains of northeastern Oregon. Table I-II shows the progression of visibly defoliated areas in Oregon and Washington between 1970 and 1987.

TABLE I-I

Western Spruce Budworm Control Projects
Oregon and Washington
1949 -- 1988

	Thousands of Acres	
Year	Oregon	Washington
1949 [1/]	267.0	-
1950	907.4	25.9
1951	801.6	125.0
1952	529.6	134.6
1953	369.2	-
1954	67.7	-
1955	620.9	-
1958	818.0	-
1962	-	46.2
1976 [2/]	6.9	351.1
1976 [3/]	-	7.7
1977 [3/]	0.7	356.0
1979 [3/]	34.4	-
1982 [3/]	69.3	-
1982 [4/]	9.2	-
1983 [3/]	02.0	-
1983 [5/]	12.5	-
1983 [6/]	10.1	-
1985 [7/]	41.0	-
1987	94.0	44.1
1988	607.5	-

1/ DDT used in all projects 1949 through 1962 (1 lb./gal.oil/A)
2/ Malathion ULV used (13 fl. oz./A)
3/ Sevin-4-Oil (carbaryl) used (1 lb./1/2gal. oil/A)
4/ Orthene (acephate) used (1/2 lb./1 gal. water/A)
5/ B.t used (12 BIU/3 qts. water/A)
6/ Zectran (mexacarbate) used (.15 lb./1gal. oil/A)
7/ Operational evaluation of five different B.t treatments

TABLE I-II

Area Visibly Defoliated by Western Spruce Budworm
Oregon and Washington
1970 -- 1986

	Thousands of Acres		
Year	NE Oregon *Blue Mtns.*	E Side OR *Cascades*	E Side WA *Cascades*
1970	14	-	0.2
1971	28	-	18
1972	23	-	202
1973	48	-	282
1974	2	7	564
1975	8	11	513
1976	0.4	11	1,089
1977	-	19	1,176
1978	-	6	193
1979	-	29	378
1980	6	-	127
1981	313	-	30
1982	1,531	-	9
1983	2,373	66	38
1984	2,884	160	53 [1/]
1985	3,600	640	420
1986	4,545	1,024.3 [2/]	448.2
1987	2,875	913	466

1/ 12,000 acres defoliated near Rimrock Lake; first time budworm defoliation ever recorded in this area.
2/ On the west side of the Oregon Cascades (Willamette NF), 89,570 acres of visible defoliation were noted.

East Slope of Oregon Cascade Range

In the mid to late 1970's a relatively small infestation of western spruce budworm occured on the the east slope of the Oregon Cascades in the Warm Springs Indian Reservation. Insecticides were applied in 1976, 1977, and again in 1979. The population subsequently collapsed in 1979. Populations in this area have again increased.

Budworm defoliation in the current epidemic was first detected from the air on the east slope of the Oregon Cascades in 1983. At that time the infestation covered a total of about 66,000 acres of the Mt. Hood National Forest and adjacent State and private lands, as well as areas within the Warm Springs Indian Reservation. Defoliated acreage increased to 160,000 in 1984, including some areas within the Deschutes National Forest. The defoliation had increased to about 640,000 acres in 1985, and to about 910,000 acres in 1986. An epidemic of this size has not been seen on the eastern slope of the Oregon Cascade Range since the late 1940's. A smaller, 34,000-acre infestation on the Warm Springs Indian Reservation, which began in 1974, was treated with insecticide in 1979.

Blue Mountains of Northeastern Oregon

A major budworm outbreak in the Blue Mountains of Oregon began in about 1980 and is continuing. Insecticides were applied to portions of the affected area in 1982, 1983, 1985, 1987, and 1988. During a 1985 aerial survey, defoliation was again detected over most of the area treated in 1982 and 1983.

Budworm defoliation was first detected in the Blue Mountains during a summer, 1980 aerial survey. Approximately 6,000 affected acres were mapped in the Mill Creek Drainage near Cove, Oregon. By late

summer of 1981, the number of defoliated acres had risen to 300,000. During the fall and winter of 1981, an environmental analysis of the situation led to a suppression project which was conducted the following summer. The insecticides Carbaryl and acephate were applied over 178,549 acres in the Umatilla and Malheur National Forests.

In August 1982, an aerial detection survey showed the infestation had spread to include about 1.5 million defoliated acres. Based on another analysis, a second suppression project was conducted. Biological insecticides were applied over 12,472 acres of these two Forests during the summer of 1983.

The defoliated acreage increased to 2.4 million in 1983, prompting another analysis. A small 850-acre field test of the biological insecticide *Bacillus thuringiensis (B.t.)* was conducted on the Ochoco National Forest. In 1984, defoliation covered 2.9 million acres, prompting another analysis of the situation. Treatment carried out in 1985 was an operational evaluation of several formulations of *B.t.*, on about 40,000 acres of the Malheur National Forest. Defoliated acres increased to 3.6 million in 1985. In 1985 and 1986, an analysis was again conducted, this time considering only a no-treat area and one in which *B.t.* was applied. No treatment was done in 1986 due to lack of suppression funds. The epidemic increased to include 6 million acres in 1987. In 1987, 135,000 acres were treated on the Wenatchee and Malheur National Forests. In 1988, approximately 600,000 acres were treated on the Mt. Hood National Forest, Umatilla National Forest, the Warm Springs Indian Reservation, and the Umatilla Indian Reservation.

Eastern Slope of the Washington Cascade Range

On the east side of the Cascade Range in Washington, western spruce budworm defoliation was first detected on the Okanogan and Wenatchee National Forests in 1970. This infestation increased to include over 1 million acres in 1976 and 1977. Insecticide treatment was carried out in 1976 (358,000 acres) and 1977 (356,000 acres). The remaining (untreated) populations seemed to diminish significantly in 1978. Defoliation was again detectable in the original infestation area by 1983. Different areas of defoliation began appearing in 1978 on and adjacent to the Tonasket Ranger District of the Okanogan National Forest. Defoliation has been detected to varying degrees since that time. In 1986, 448,000 acres of infestation were mapped. This acreage included some previously treated areas.

On the Naches Ranger District, Wenatchee National Forest, 12,000 acres of budworm defoliation were mapped in 1984, 134,000 acres in 1985, and 80,610 acres in 1986. No previous western spruce budworm defoliation had been reported in this area.

1988 Suppression Projects

The 1987 summer aerial detection survey, and a subsequent egg mass and defoliation survey, revealed that budworm populations had not collapsed. The defoliated area then covered nearly 6 million acres in Oregon and Washington. This might seem to imply that the insect populations spread widely from a common geographic source. Evidence indicates though, that endemic populations in various locations expanded simultaneously, primarily in response to favorable weather conditions. The infestation has spread without regard to ownership or jurisdictional boundaries. A potential now exists for significant impacts on the management objectives and practices of many private and public land managers.

In 1988 a major set of suppression and developmental projects was conducted in Oregon to deal with current epidemic levels of infestation.

Programmed treatment areas on the Mt. Hood National Forest were sprayed with *B.t.* The following results were recorded: The Dalles, $2.40 \pm .36$ larvae/45 centimeter branch tip on an area of 116,000 acres; Barlow, $0.56 \pm .07$ larvae/tip on an area of 140,000 acres; and Warm Springs, 0.57 larvae/tip on an area of 186,000 acres. The Dalles unit did not meet acceptable control limits specifications. A spray assessment indicated that poor application had been performed over considerable acreage there. Added to this were Very high populations of budworm in the unit.

The Tollgate project on the Umatilla National Forest showed results of $0.55 \pm .008$ larvae/tip and $0.68 \pm .02$ larvae/tip respectively, over approximately 107,000 acres. Wallowa-Whitman project results were $1.42 \pm .15$ larvae/45 centimeter branch tip over approximately 2,000 acres.

Projects conducted by Longview Fibre (a wood products company) and Hood River County used both carbaryl and *B.t.* Over an area of 33,000 acres, carbaryl reduced populations to less than 1 larvae/45 centimeter branch tip on 14 out of 15 spray blocks. *B.t.* gave variable results over 6,700 acres, with two out of five blocks averaging less than 1 larvae/tip. The difference in results may be due to differences in spray deposit. The average droplet density on spray deposit cards was 25 drops/square centimeter for carbaryl, whereas *B.t.* averaged 14 drops.

In a pilot project conducted near Meacham, Oregon, to determine the feasibility of using undiluted

formulations of *B.t.* at 43 oz. (16 BIU)/acre, the following results were obtained: *B.t.* formulation Dipel 6AF, 2.17 larvae/45 centimeter branch tip, 87.8 percent population reduction; *B.t.* formulation Thuricide 48LV, 1.03 larvae/tip, 94.7 percent population reduction; and the untreated area 7.83 larvae/tip, 54.7 percent population reduction. Though these are preliminary results, it appears that only Thuricide 48LV met the criteria of reducing the population to less than 1 larvae per tip.

A special project was conducted on the Mt. Hood National Forest to evaluate the handling and application of two formulations of *B.t.* Dipel 6L was applied undiluted at 42.7 oz. (16 BIU)/acre and Thuricide 32LV was applied undiluted at 64 oz. (16 BIU)/acre. Preliminary results indicate that both formulations reduced populations of budworm to below the 1 larvae/45 centimeter branch tip threshold. Thuricide 32LV reduced populations to $0.28 \pm .08$ larvae/tip. Dipel 6L reduced populations to 0.90 larvae/tip.

Public Involvement

Meetings have been conducted with Government agencies, special interest groups, industry representatives, and interested individuals.

A brochure requesting comments and concerns was mailed to approximately 2,000 groups and individuals to help identify Issues and concerns. Press releases were mailed to the media near areas where western spruce budworm infestations have been documented.

A total of 206 responses were received through distribution of the scoping brochure and included approximately 550 substantive comments. These comments were analyzed to identify Issues, proposed new Alternatives, and viable analysis criteria needed to evaluate the possible Alternatives.

In October 1988, a Draft Environmental Impact Statement on the management of the western spruce budworm in Oregon and Washington was printed. Approximately 1000 copies of the DEIS and 2000 copies of the summary were mailed to interested parties.

A total of 101 responses were received through distribution of the DEIS and summary and included approximately 1244 substantive comments.

Major Issues And Concerns

In the years since 1981, when budworm infestations reached readily verifiable epidemic proportions in the Region, Environmental Assessments (EAs) have documented a growing concern for affected resources and for the effects of chemical suppression efforts. Issues and concerns identified during a 1984 northeastern Oregon analysis were used to help generate public involvement in 1985. 'Scoping' efforts in 1986 included public meetings and written inquiries to concerned citizens. In 1986, 1987, and 1988, public meetings were held on individual Forests. In addition, letters were written to interested parties; to elicit and identify Issues and concerns that had not been specifically addressed in previous EAs. Public meetings, personal interviews, news clippings, and written correspondence resulted in identification of public Issues and management concerns. The Issues identified by these means reflect the views of concerned individuals, forest-based industry representatives, landowners of various-sized forest holdings, forest resources user groups, conservation and environmental groups, Native American tribes; as well as representatives of local, State, and Federal agencies and governments.

Based on responses to mailed inquiries, and concerns identified in a broad sampling of past EAs; nine major public Issues were identified in the scoping process conducted for this EIS. They include silviculture; water quality and quantity; fire and fuels; fish, wildlife, and domestic animals; scenic values/recreation economics; human health; effectiveness of treatment methods; and timeliness of treatments. A discussion of these issues follows:

Silviculture

The effects of budworm infestations on timber production are complex, whether treatment is initiated or not. Long-term management of timber stands through silviculture treatments, as a means to end the epidemic, is an Issue. Western spruce budworm suppression efforts would only serve to lessen short-term growth losses. However, any long-term solution will take decades to implement and thus ineffective in treating the present outbreak.

Concern has been expressed that untreated budworm infestations may negate efforts to increase timber growth rates through intensive timber management, and that long-term yields and harvests may be reduced from present levels. It has been suggested that budworm suppression using insecticides will be needed until areas contain healthy, mixed-species

stands which are less vulnerable to budworm infestation. There is concern that past silvicultural practices have led to species composition and stand conditions that are more vulnerable to spruce budworm infestations and resulting damage.

Water Quality/Quantity

Two broad areas of concern are included in this Issue: possible hydrologic changes that might occur in watersheds if the budworm epidemic is left unchecked, and possible contamination of water quality from the use of insecticides. Some members of the public have asserted that widespread defoliation may result in variations in the quantity of water yield in heavily affected watersheds; that increased flows could result in streambank cutting and greater sediment loads. Hydrologic changes could also affect unstable slopes and cause increased mass failure activity.

A number of people are concerned about monitoring activities. They believe that monitoring should adequately assess both the short- and long-term effects of treatment on water quality and riparian zones.

Most concern about possible water quality diminution centers on the use or accidental spills of chemical insecticides. The nature of ingredients in *B.t.* formulations and the use of spreader/sticker agents in this biological insecticide are also a concern. Individuals have expressed concern about possible adverse effects on aquatic life and irrigation water. However, the central issue involves direct human use of water that may contain insecticides. Protection of water quality in Oregon and Washington municipal watersheds, such as those of The Dalles, Dufur, and Walla Walla, is of great concern.

Fire And Fuels

Many years of effective fire suppression have resulted in unprecedented accumulations of needle litter, dead limbs, and dead trees; which can lead to high intensity wildfires. Infestations of mountain pine beetle, western spruce budworm, and Douglas-fir tussock moth have also contributed to fuel loads. Recent insect epidemics have increased the rate of accumulation. Four typical conditions signal threats of wildfire.

1. Areas of dead and down woody debris created from insect mortality;

2. Timber stands at higher elevations where there is historically a high rate of ignition by lightning;

3. Precommercial thinning slash;

4. Areas containing high rate-of-spread fuels, such as logging slash.

Fish, Wildlife, And Domestic Animals

People are concerned that fish, wildlife and domestic animals could be adversely affected by the budworm infestation or by insecticide application.

Big game species may be affected if budworm defoliation changes the quantity and/or quality of the coniferous overstory which is used for thermal cover, hiding, and escape. Some people expressed concern that deer and elk may be adversely affected by ingesting insecticides on forage. Since spraying of insecticides usually occurs about the same time as spring birthing, some people expressed concern about the effects of increased human disturbance (increased desertion of young, increased vulnerability to predation) during this critical biological activity. Bighorn sheep deserting their young as a result of human disturbance was a concern mentioned in particular.

Concerns were also expressed about possible adverse effects of insecticides on vertebrate species (birds, small rodents, and squirrels) that consume budworms and other insects. While insectivorous bird species were mentioned most often in this regard, concern was also expressed for several species of raptors, geese, flying squirrels, bats, toads, lizards, salamanders, and snakes. Other concerns were expressed for federally classified Threatened or Endangered species; and that a reduction in food supply for several species could cause relocation and reduction in nestling survival.

Concerns were expressed about possible adverse effects of insecticides on natural predators of the budworm, which might upset the natural balance and result in a need for yearly treatment. Possible adverse effects on pollinator species and livestock were also a concern.

Many people expressed a strong desire for monitoring programs which would better assess the direct and secondary effects of insecticide application on nontarget species. These data, they surmised, would then provide a better source of information upon which to base future budworm suppression decisions.

The same concerns described for terrestrial wildlife were also expressed for aquatic wildlife. The greatest concern involved possible adverse effects to fish (native and anadromous), either through direct exposure to insecticides or through reductions of aquatic insect food supplies. The safety of human consumption of fish from oversprayed streams was also a concern. Many people believe stream buffers are the only measures used to protect aquatic

resources. The need for monitoring direct and secondary effects was emphasized.

Scenic Values/Recreation Use

The potential impact of spruce budworm damage on scenic viewscapes is a concern to many people. A reduction in recreational use (campgrounds, picnic areas, fishing, hiking, etc.) due to spruce budworm infestations is an Issue, as are the economic implications of these reductions.

Economics

Nearly all members of the public want to know if their money is being spent wisely. Most have suggested that the benefits and costs of Alternatives being considered should be displayed and compared. Opinions have been expressed regarding factors that should enter into the economic efficiency analysis and the appropriateness of assumptions used in past analyses. Benefits and costs associated with the following factors have been suggested for consideration: timber growth loss, effectiveness of *B.t.* compared to carbaryl, risk of budworm population resurgence or reinvasion, and reduced recreation use.

Concerns have been expressed for the possible economic effects on private landowners if a "No Action" decision were made. Where private land is adjacent to designated Wilderness, for instance; will policy not allow for treatment of infestations?

Concern has been expressed for possible reductions in National Forest timber harvest levels because of the budworm outbreak, and subsequent effects on employment and community stability.

Human Health

Most people who have expressed concern with budworm control projects want an understanding of possible hazards associated with the use of the insecticides being considered. The potential for long-term, short-term, and cumulative effects on human health is a concern. Possible effects on pregnant women, children, older people, and chemically sensitive people have been mentioned.

Most people believe high priority should be given to preventing accidents and spills; and that if mishaps occur, the response should be swift and appropriate. Timely public notification should be given so people can avoid treatment areas. Emphasis on safety should be given throughout contract preparation, contract administration, and all operational phases of a spray project.

Many of the people showing an interest in budworm control programs expressed a preference for continued biological rather than chemical insecticides. There are concerns about cumulative health risks from existing chemical use in the environment, and for what additional chemical pesticide applications will add to human health hazards.

Effectiveness Of Treatment Methods

Concern was expressed about the effectiveness of available treatment methods in managing the western spruce budworm infestation. The effectiveness of insecticides is dependent upon application techniques and proper timing. The efficacy of a biological insecticide is more dependent upon weather conditions than are the chemical insecticides. Unlike chemical insecticides, biological insecticides must be ingested by western spruce budworm larvae to be effective. Treating too early can result in many individual larvae escaping exposure to *B.t.*, because they are not yet feeding on foliage that is sprayed. The effectiveness of *B.t.* might also be diminished by exposure to sunlight before being ingested by larvae. Treatment administered too late might result in avoidance of *B.t.* by larvae that have advanced into the late sixth instar and have ceased feeding prior to pupation.

Timeliness Of Treatments

Throughout its range, populations of the western spruce budworm appear to persist in stands that contain a substantial proportion of suitable host trees. Some people felt that immediate suppression action could limit the spread of an infestation and prevent a widespread epidemic.

Planning Questions:

Analysis of public responses shows that many of the Issues and concerns were interrelated to some degree. Those most closely interrelated have been grouped into eight planning questions. (Suppression using silviculture management techniques was eliminated as an option to be studied in detail, since implementation would take decades and would have little or no visible effect on the current epidemic):

1. What are the hydrologic effects of treatment/nontreatment?

Concerns have been raised regarding the effects of the western spruce budworm infestation upon water quality and quantity. Some feel defoliation and tree mortality influence snowpack levels, seasonal snowmelt, stream temperatures, turbidity, and overland

flows. Increased sediment associated with salvage of mortality is also a concern.

2. What is the effect of budworm treatment or nontreatment on the potential for wildfire?

As needles, branches and entire trees drop to the forest floor, fuel loading increases. What is the likelihood and potential impact of an uncontrolled fire event under the various management options?

3. What are the effects of each alternative on fish, wildlife, and domestic animals?

Concerns that the increased human activities associated with suppression projects will disturb deer and elk during fawning and calving have been raised. Some people feel that fawns and calves would be more vulnerable to predation because of increased chances of desertion by the mothers. There are concerns about the health effects on wildlife resulting from use of *B.t.* or carbaryl.

4. What is the effect of budworm treatment or nontreatment on scenic values and recreation use?

Timber stands affected by the current spruce budworm outbreak will suffer various types and degrees of damage to the visual quality of forest landscapes. Treatment would avert most of the future predicted loss due to the current outbreak.

5. What are the economic implications of the proposed Alternatives?

The potential losses in timber growth and yield due to foliage loss are a key concern. Visual resources are also affected by spruce budworm as foliage discolors or trees die. This may have an effect on the economies of small communities which are dependent, in part, on recreation income. Suppression projects will bring dollars to local economies by creating employment opportunities for citizens and will also increase the demand for goods and services.

6. What are the effects on human health associated with treatment using insecticides?

It is recognized that some segments of the public have concerns about pesticide use. It is perceived that these insecticides either pose an immediate hazard to human health, or have the capacity to cause health problems in the future.

7. How effective are available treatment methods in reducing the insect population? (Efficacy)

The efficacy of *B.t.* and other pesticides is directly related to the method of application, weather, and timing. High quality *B.t.* applications, as well as high quality carbaryl applications, are likely to suppress budworm populations below an average of 1 larva per branch tip.

8. What is the timeliness of treatment for this and future epidemic cycles?

Concerns have been raised about the time lapse between the onset of the epidemic and the start of treatment. What is the most effective timing of treatment? Can early treatment stop widespread infestation?

USDA Forest Service Management Objectives

Management direction provided through laws, regulations, and policies, is described in a number of places. The following references contain material applicable to Alternatives being considered in this analysis: (These references are available at the USDA Forest Service, Pacific Northwest Regional Office in Portland Oregon).

Laws, Regulations, And Policies

Preservation of Wilderness Values; Wilderness, Primitive Areas, and Wilderness Study Areas. Where a choice must be made between Wilderness values and the value of any activity which affects Wilderness resources, preservation of the Wilderness resource is the overriding policy. Economy, convenience, commercial value, and comfort are not standards for Wilderness management. Because the human uses and values of each area vary, management and administration of wilderness must be tailored on a case by case basis. Even so, all Wilderness Areas are part of one National Wilderness Preservation System. Their management must be consistent with the Wilderness Act and other established legislation. The Wilderness Act states that insect or disease outbreaks will not be artificially controlled unless it is necessary to protect resources outside the Wilderness. Insect or disease suppression projects in National Forest Wildernesses shall be based on factors set forth in FSM 3400/2320, and be approved by the Chief of the Forest Service.

Oregon and Washington State Forest Practices Acts. The Oregon Forest Practices Act provides a set of rules, establishing minimum standards for encouraging and enhancing the cultivation and harvest of trees on State, Federal and private lands. At the same time, the Act considers and protects other environmental resources - air, water, soil, and wildlife.

A key element in the Washington Forest Practices Act is the emphasis on flexibility and site-specific prescriptions. An interagency approach toward forest practices is emphasized; to ensure that impacts to soils, water quality, and habitat are accurately assessed.

Any project to be implemented in Oregon and Washington must comply with the laws, rules, and regulations of these Acts. (Available at Oregon Department of Forestry offices or Washington Department of Natural Resources offices)

Federal Insecticide, Fungicide, and Rodenticide Act of 1972 as amended (Public Law 92-516). This Act is the authority for the registration, distribution, sale, shipment, receipt, and use of pesticides. The Forest Service may use only pesticides which are registered or otherwise permitted, in accordance with the Federal Insecticide, Fungicide, and Rodenticide Act, as amended.

Environmental Protection Agency Regulations. These regulations include air and water quality standards that must be met. The U.S. Environmental Protection Agency (EPA) has responsibility, under a variety of statutes, to protect the quality of the Nation's ground water and air quality. The EPA is also directly responsible for regulating the availability and use of pesticide products. Since the early 1970's, the EPA's office of Pesticide Programs has been evaluating the leaching potential of new and existing pesticides. It has taken regulatory actions, to restrict or prohibit the use of pesticides found to have the potential to contaminate ground water. During this period, the EPA has also undertaken monitoring studies and research efforts designed to help identify the risks pesticides pose to ground water and air quality.

Endangered Species Act. This Act serves to protect plant or animal species identified by the Secretary of Interior as Endangered or Threatened, in accordance with the 1973 Endangered Species Act, as amended. The National Forest Management Act requires that viable populations of Sensitive species be maintained, to ensure they do not become Threatened or Endangered as a result of Forest Service actions. Population and/or habitat objectives need to be developed and implemented for most of the species listed by the Regional Forester.

Other Laws, Regulations, or Policies. Any implemented project will comply with other applicable local, State, and Federal laws, regulations, or policies.

Land Management Plans. Treatments will comply with the direction provided in the most recently approved Land Management Plan for National Forest System lands.

USDA Forest Service Goals

A principle U.S. Department of Agriculture goal is to ensure an adequate supply of high quality food and wood fiber, and a quality environment for the American people. The USDA gives special emphasis to the development and use of efficient and environmentally acceptable integrated insect and disease management systems.

Insect epidemics will be prevented or suppressed by methods that will restore, maintain, or enhance the quality of the environment. These objectives may be attained on non-Federal lands through cooperation with State Foresters or equivalent State officials. Insects are suppressed directly on National Forest lands and in cooperation with responsible officials on other Federal lands. The Forest Service has share-cost agreements with the States of Washington and Oregon. These agreements allow the Federal Government to pay for a portion of the spruce budworm suppression costs on private lands.

Integrated Pest Management

The USDA Forest Service Pest Management Policy is built upon the concept of Integrated Pest Management (IPM). IPM is an ecologically based approach that prescribes the following types of activities: monitoring, prevention, suppression, and evaluation.

Forest Service land management objectives rely, in part, on the use of prescribed IPM prevention methods. The ecological principles relating to pest management are incorporated into forest and range management evaluations, planning, and decisionmaking. IPM has designed an intensive, continuing means for detection and evaluation of pest populations. Information from IPM is supplied to program planners and decisionmakers. The fundamental intent of prevention is to avoid creating ecological conditions that foster pests, or to correct management-created conditions that would allow continuing pest problems.

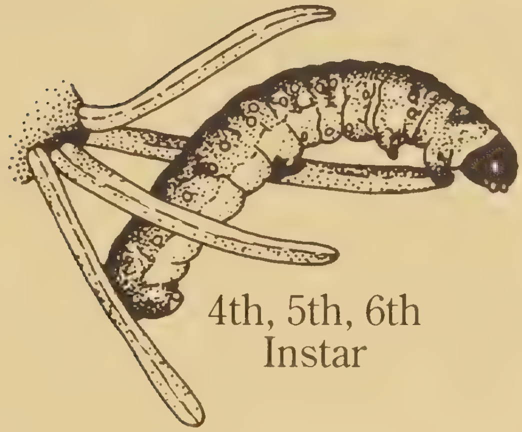
Suppression, as related to IPM, involves evaluating the spectrum of possible suppression options and, in each case, selecting the optimal strategy. That strategy may be a single tactic, concurrent measures, or a sequential combination of tactics. The evaluation considers the expected effectiveness of treatments in achieving resource management goals, as well as such factors as economics, environmental concerns, and human safety. Suppression takes two forms: direct and indirect. Direct suppression means taking action

directly against a pest to reduce its population. For example: spraying insecticides, using prescribed fire, removing pests contained in infested materials, or releasing parasites or predators. Indirect suppression is similar to prevention since it involves altering conditions that foster a pest population growth, thereby causing a decline in numbers. Indirect suppression methods are applied to existing pest populations, with the intent of limiting damage to tolerable levels.

Post-suppression activities include monitoring and post-treatment evaluations to determine the effectiveness and efficiency of suppression efforts. Effectiveness evaluations are ideally made in terms of net resource value changes rather than pest population numbers. To improve overall program performance, information gathered during the post-suppression phase is fed back into the system, and appropriate adjustments are made to pest management strategies.

A feature of IPM is the consideration given to potential pest problems when making individual situation analyses. The goal is to avoid creating or intensifying one pest problem while attempting to alleviate another. The strength of the IPM philosophy is that it requires the three phases of pest management be incorporated into the broad arena of forest and range management. IPM is found in the planning, decisionmaking, and program implementation functions.

Chapter 2: Alternatives



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CHAPTER II. ALTERNATIVES, INCLUDING THE PROPOSED ACTION

This chapter describes options for managing western spruce budworm populations in forests of the Pacific Northwest. In the pages which follow, five fully developed Alternatives are presented. Their physical, biological, social, and economic effects are compared. Environmental consequences of implementation of the Alternatives, which are explored in Chapter IV, have provided the basis for these comparisons. Included also in Chapter II are those alternatives which were considered but eliminated from detailed study.

Introduction

This Environmental Impact Statement (EIS) considers four different ways of managing western spruce budworm populations. A "No Action" Alternative is described first. This Alternative prescribes no management actions and allows for no treatment of budworm infestations. The second Alternative prescribes the use of a biological insecticide; the third, a chemical insecticide. The fourth Alternative allows for the use of either the biological or the chemical insecticides. The fifth and final "action" Alternative prescribes the use of a biological insecticide, but allows for treatment with the chemical 'carbaryl' in rare and extraordinary instances.

These Alternatives represent the only viable means of suppressing the current budworm outbreak. Possibilities of preventing or reducing epidemic growth of budworm populations in the future are discussed under **Alternatives Eliminated from Detailed Consideration** and in Chapter I, under **Scope of Decision**.

Alternatives Eliminated From Detailed Study

In developing the Alternatives which are considered in detail, the Forest Service began with a wide range of treatment options. Those alternatives which were eliminated from detailed consideration, and the rationale for their elimination, are:

Suppression Using Biological Methods Other Than *B.t.*

Three types of biological control techniques have been used with some success against other insect pest species and have been suggested for use on the western spruce budworm. A brief description of these techniques, and the reasons they were not studied in detail, are listed below.

Sterile Male Release

This technique involves the sterilization, in the laboratory, of male specimens of the target species. These males would be irradiated or treated with chemicals, and released in the field. They would mate with females that would produce sterile offspring or no offspring at all. In theory, this should cause a decline in population growth. This suppression technique has shown some success in treating gypsy moth infestations, but no experiments have documented its effectiveness against the western spruce budworm. For this reason, it was eliminated from further study.

Parasite or Predator Augmentation

This technique involves rearing parasites or predators of the target species, to be released into infested areas; or, the manipulation of factors in the environment which would cause native parasite or predator populations to increase. Theoretically, these methods would help reduce pest species' populations to non-damaging levels. They have been tried on a number of other native forest defoliators though, and have shown little success. Western spruce budworm populations have not been significantly affected by this kind of treatment. This option was therefore been eliminated from detailed study.

Pheromone Manipulation

This technique involves the use of pheromones chemicals, normally produced by female moths to attract male moths. In the late spring, when adult moths emerge from the pupae, synthetic pheromones are applied to infested areas. This form of treatment makes it difficult for males to locate and mate with

females. The females therefore produce no offspring, and a population decrease results. This technique has produced some success in treatment of Douglas-fir tussock moth infestations, but it has not yet been shown to be effective against western spruce budworm. It is therefore not considered a realistic control option, and was not developed in further detail.

Indirect Suppression Using Silvicultural Techniques

This option describes a set of management strategies which would serve to reduce a forest's susceptibility or vulnerability to infestation. While these strategies are considered viable means for reducing future infestations, their application can only be effected over many successive years of management activities.

Long-term treatments propose to counteract the cumulative effects of wildfire exclusion and past harvest activities (partial cutting and serial selection cutting). Over a period of many decades the successional trend toward climax vegetation would be reversed. On East-side forests this corrective management strategy would progressively replace mixed-conifer stands with trees that are resistant to western spruce budworm. Moreover, stand composition would be manipulated to lessen susceptibility to budworm infestations and vulnerability to damage.

Recent research in eastern Oregon indicates that increased foliage resultant from nitrogen fertilization, may compensate for foliage consumption from a dense budworm population. This information was derived from analysis of data gathered from experimental plots on the Malheur National Forest. Installation of experimental plots on the Umatilla and Wallowa-Whitman National Forests was completed in October, 1988. None of these studies has been completed. If fertilization does produce favorable results, an operational program would not be realistic for 5 to 10 years. Consequently, fertilization is not a reasonable option for treating the current budworm epidemic and has been eliminated from detailed study in this document.

Suppression Using the Chemical Insecticides Mexacarbate, Acephate, and Malathion

Mexacarbate was used in 1983 to treat a 10,000 acre infestation of western spruce budworm on the Malheur National Forest. Results of its application were inconclusive. Budworm populations were not reduced to below the threshold established as acceptable (Bridgwater, 1983). The apparent ineffectiveness of treatment and the fact that Mexacarbate is no longer being manufactured, have left entomologists no longer interested in developing its use (Flavell et al., 1977; Stipe et al., 1977; Livingston et al., 1982).

Acephate was used in 1982 on the Malheur National Forest, and showed promise in small-scale field and pilot projects. Populations were reduced to a level averaging 9.1 larvae/100 buds, but treatment did not prevent significant defoliation (Hostetler, 1983).

Malathion has been inconsistent in suppressing populations of budworm in the Northwest. In 1976, it was applied over 358,000 acres in Washington and Oregon. About 123,000 acres were retreated in 1977, because budworm populations had remained at damaging levels (Mounts et al., 1978).

Moreover, entomologists do not recommend the use of these chemical insecticides. This alternative was therefore eliminated from detailed study.

Alternatives Considered In Detail

In this part of Chapter II the five Alternatives which were considered for implementation are briefly described. They are Alternatives which were designed to respond to identified planning questions. Mitigation measures are listed in Chapter IV by specific resource and in Appendix C, Standards and Guidelines.

Objectives Used in Designing "Action" Alternatives

The Issue-driven objectives common to all action Alternatives are:

1. To Meet or exceed existing water quality standards;
2. To Maintain wildlife habitat and populations;
3. To Minimize any potential risks to human health and the human environment;
4. To use only effective and economically sound methods of management.

Alternative A (No Action)

This Alternative allows no intervention in the western spruce budworm infestation cycle. The epidemic would run a course subject only to natural, unpredictable controls. Western spruce budworm activity would be monitored annually. An aerial "sketchmap" survey would determine the extent of visible defoliation. The No Action Alternative forms a baseline against which all other Alternatives are compared.

Current management practices in the infested areas would continue, though scheduling and timing of these activities could be directly affected by the budworm outbreak. Silvicultural prescriptions would be changed as needed, to respond to damage in individual Forests.

Alternative B

This Alternative provides for a direct suppression strategy using the biological insecticide *B.t.* only. Suppression projects would be designed to protect those timber, recreation, and visual resources which are expected to sustain unacceptable damage. Treatment would involve the aerial application of *B.t.* to selected areas. Alternative B would reduce western spruce budworm populations to non-damaging levels. Depending on post-treatment population increases caused by resurgence or reinvasion, retreatment of affected areas would be performed as needed.

Current management practices in the infested areas would continue, though scheduling and timing of these activities could be directly affected by the budworm outbreak. Silvicultural prescriptions would be changed as needed, to respond to damage in individual Forests.

Future treatment costs are based on the number of years an analysis area has sustained visible defoliation. A cost for only one treatment is projected for areas where there has been visible defoliation for five years or more. The cost of two treatments is projected for areas where there has been visible defoliation for less than five years. Analysis areas where the age of visible defoliation varies over the landscape may also require two treatments.

Alternative C

This Alternative prescribes a direct suppression strategy which requires application of the chemical insecticide 'carbaryl'. At this time, carbaryl is recognized as the most effective chemical insecticide available for suppressing budworm populations. It is registered with the Environmental Protection Agency (EPA) as safe for forest application. Although three other chemical insecticides are similarly registered with EPA; malathion, acephate, and mexacarbate; only carbaryl would be allowed under Alternative C.

Suppression projects would be conducted to protect those resources which are expected to sustain unacceptable damage. Carbaryl would reduce western spruce budworm populations to non-damaging levels over most affected acres. Application of carbaryl would involve aerial "broadcast" treatment of infested areas. A strip of untreated vegetation would always be left adjacent to streams and around other bodies of water when this chemical is used. The objective of Alternative C is to reduce budworm populations to nondamaging levels for the extent of the current epidemic. Depending on post-treatment population increases caused by resurgence or reinvasion, retreatment of affected areas would be performed as needed.

Current management practices in the infested areas would continue, though scheduling and timing of these activities could be directly affected by the budworm outbreak. Silvicultural prescriptions may be changed as needed, to respond to damage in individual forests.

Future treatment costs are based on the number of years an analysis area has sustained visible defoliation. A cost for only one treatment is projected for areas where there has been defoliation for five years or more. The cost of two treatments is projected for areas where there has been visible defoliation for less than five years. Analysis areas where the age of defoliation varies over the landscape may also require two treatments.

Alternative D

This Alternative provides for the use of either *B.t.* or carbaryl. Alternative D proposes suppression projects which would protect resources at risk of unacceptable damage. Application of *B.t.* would be allowed adjacent to but not over streams and other bodies of water. Treatment with carbaryl would be allowed over treatment areas in special instances, but untreated buffer zones would be maintained around streams and other bodies of water. Whether carbaryl or *B.t.* is used in a treatment area would be determined on a site specific basis. The proximity of human habitation or the frequency of human use in proposed treatment areas will be considered in every decision.

Current management practices in the infested areas would continue, though scheduling and timing of these activities could be directly affected by the budworm outbreak. Silvicultural prescriptions would be changed as needed, to respond to damage in individual Forests.

Future treatment costs are based on the number of years an analysis area has sustained visible defoliation. A cost for only one treatment is projected for areas where there has been visible defoliation for five years or more. The cost of two treatments is projected for areas where there has been visible defoliation for less than five years. Analysis areas where the age of visible defoliation varies over the landscape may also require two treatments.

Alternative E (Preferred)

This Alternative was developed in consideration of public comments and concerns which addressed the Draft EIS. It is largely a composite of elements

described in Alternatives B and D. This Alternative provides for direct suppression of budworm infestations. The biological insecticide *B.t.* is defined as the treatment of choice. However, carbaryl may be used in the event that *B.t.* is unavailable or is expected to be ineffective in site-specific instances. Situations in which the use of carbaryl might be warranted are:

- When *B.t* is not available.
- When high value stands are infested by rapidly expanding western spruce budworm populations and effective insect control requires an insecticide that has both contact and residual properties.
- In research and pilot test projects designed to evaluate unproven formulations or reduced dosages.
- When a Regional Entomologist's analysis recommends its use.

The decision to use *B.t.* or carbaryl within treatment areas will be made in project-specific environmental analysis. The resources and environment within each area will be considered in the decision making process. The proximity of human habitation or the frequency of human use in proposed treatment areas will be considered in every decision. Formulations of *B.t.* could be applied adjacent to but not over streams or other bodies of water. Treatment with carbaryl would require that an untreated buffer strip be maintained along streams or around other bodies of water.

Multiple-use management practices in the infested areas will continue, though scheduling and timing of these activities may be affected by the budworm epidemic. Silvicultural prescriptions will be changed as needed, to respond to respond to damage in individual Forests.

A comparison of these Alternatives follows:

Comparison Of Alternatives

Planning Question #1:

What are the hydrological effects of treatment and nontreatment?

Alt. A. (No Action)	No significant increase in annual streamflow or peak discharge is anticipated as a direct result of defoliation and mortality. Cumulative effects of extensive management activities, combined with defoliation, could produce significant increases in annual streamflow. These increases could degrade water quality. Defoliation and mortality could promote slight increases in water temperature in some stream segments.
Alt. B. (Use of *B.t.* only)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.
Alt. C. (Use of Carbaryl only)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.
Alt. D. (Use of *B.t.* and/or Carbaryl)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.
Alt. E. (*B.t.* as primary insecticide)	This Alternative would reduce defoliation and lessen impacts described in the No Action Alternative.

Planning Question #2:

What are the effects of Alternatives on fuels and fire?

Alt. A. (No Action)	A minimum impact on fuel loading in areas where only scattered mortality has occurred; severe defoliation and high levels of mortality will result in significant increases to fuel loading; fire intensity is expected to be high in continuous areas of mortality; fire line construction wil be slowed by heavier fuels.
Alt. B. (Use of *B.t.* only)	Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.
Alt. C. (Use of Carbaryl only)	Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.

Alt. E. (*B.t.* as primary insecticide)	Short-term potential for heavy fuel buildup would be reduced or eliminated; scattered mortality would occur; existing fuel loading would not be significantly increased; projected fire intensity and fireline construction rates would remain constant.

Planning Question #3:

What are the effects of Alternatives on fish, wildlife, and domestic animals?

Alt. A. (No Action)	Implementation of this Alternative would result in no adverse impacts to fish or animals.
Alt. B. (Use of *B.t.* only)	Implementation of this Alternative would result in no significant impacts on fish or animals. Some resources may benefit slightly.
Alt. C. (Use of Carbaryl only)	Implementation of this Alternative may result in significant impacts to some resources. Specifically, some species of small mammals, birds, and insects may be adversely affected by the toxicological properties of carbaryl or it's carriers, diesel oil and kerosene.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Implementation of this Alternative, in compliance with prescribed mitigation measures, may result in minor impacts to some resources. Significant impacts would probably be mitigated by the use of *B.t.* in sensitive ecosystems.
Alt. E. (*B.t.* as primary insecticide)	Under ordinary circumstances implementation of this Alternative would not result in significant impacts to other resources. Some resources may benefit slightly. Implementation with carbaryl, in compliance with established mitigation measures, may result in minor impacts to some resources. Significant impacts would probably be mitigated by the use of *B.t.* in sensitive ecosystems.

Planning Question #4:

What effects would implementation of the Alternatives have on viewsheds and recreational use?

Alt. A. (No Action)	Severe defoliation will result in color and texture changes for a decade or more; changes in visual quality could result in decreased recreational use, with a corresponding impact on the recreation economy.
Alt. B. (Use of *B.t.* only)	Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.
Alt. C. (Use of Carbaryl only)	Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.

Alt. D.
(Use of *B.t.* and/or Carbaryl)

Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.

Alt. E.
(*B.t.* as primary insecticide)

Treatment would provide short-term protection of foliage; changes to color and texture of the landscape are reduced but not eliminated; cumulative mortality and top-kill would be reduced; only slight reductions in recreation use would be expected; a forest with tree species susceptible to continued defoliation would be maintained.

Planning Question #5:

What are the economic implications of the Alternatives?

Alt. A.
(No Action)

Long-term reduction in future supply of wood fiber; short-term increase of logs for manufacturing due to salvage operations.

Alt. B.
(Use of *B.t.* only)

Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.

Alt. C.
(Use of Carbaryl only)

Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.

Alt. D.
(Use of *B.t.* and/or Carbaryl)

Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.

Alt. E.
(*B.t.* as primary insecticide)

Long-term supply of wood fiber maintained; short-term increase in local demand for goods and services. Short-term increase due to spray operation.

Planning Question #6:

What are the effects on human health associated with treatments using B.t. and other chemicals?

Alt. A.
(No Action)

This Alternative would have no effect on human health, since the Alternative prescribes no chemical or biological insecticides.

Alt. B.
(Use of *B.t.* only)

This Alternative presents the least risk of the direct suppression Alternatives. The use of *B.t.* poses little risk of acute or chronic effects on human health.

Alt. C.
(Use of Carbaryl only)

This Alternative presents the highest risk to human health of any direct suppression Alternative being considered. Carbaryl poses a human health risk only in the event of accident. The petroleum-distillate carrying agents (kerosene and diesel oil), commonly used for application, present a risk under routine worst-case conditions and in the event of accidents.

Alt. D.
(Use of *B.t.* and/or Carbaryl)

This Alternative presents human health risks less that Alternative C, but greater than Alternative B. The level of risk would be reduced in proportion to the extent that *B.t.* is used instead of carbaryl.

Alt. E. (*B.t.* as primary insecticide)	This Alternative would generally present minimum risk to human health. The use of *B.t.* poses little risk of acute or chronic effects on human health. Risk to human health would be reduced to the extent that *B.t.* is applied in place of carbaryl.

Planning Question #7:

How effective are the treatment methods?

Alt. A. (No Action)	No effect on achieving lasting budworm population reductions.
Alt. B. (Use of *B.t.* only)	Applications are likely to suppress budworm populations to below identified threshold levels; populations unlikely to develop a tolerance; resurgence and reinvasion are not anticipated.
Alt. C. (Use of Carbaryl only)	Applications are likely to suppress budworm populations to below identified thresholds; budworm populations can develop a tolerance to carbaryl applications; budworm reinvasion from buffers and other adjacent untreated areas is possible; inadvertent sublethal doses can stimulate resurgence of populations.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Flexibility to use either *B.t.* or carbaryl as the situation warrants, is likely to suppress budworm populations to below identified threshold levels; use of carbaryl has potential to influence occurrence of reinvasion and/or resurgence.
Alt. E. (*B.t.* as primary insecticide)	Flexibility to use either *B.t.* or carbaryl as the situation warrants, is likely to suppress budworm populations to below identified threshold levels; use of carbaryl has potential to influence occurrence of reinvasion and/or resurgence.

Planning Question #8:

What is the timeliness of treatment for this and future outbreak cycles?

Alt. A. (No Action)	Implementation of this Alternative would allow budworm infestations to follow a natural course. It would have no effect on the frequency of future epidemics.
Alt. B. (Use of *B.t.* only)	Implementation of treatments prescribed in this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. Earlier treatment would not have prevented the "spread" of budworm infestation. The application of *B.t.* should have no effect on future outbreaks.
Alt. C. (Use of Carbaryl only)	Implementation of treatments prescribed in this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. The application of carbaryl (with buffers where appropriate) may have an effect on the ability of budworm populations to reinvade and resurge, thus affecting future outbreaks.
Alt. D. (Use of *B.t.* and/or Carbaryl)	Implementation of treatments prescribed in this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of vigorous populations.

Alt. E.
(B.t. as primary insecticide)

Implementation of treatments prescribedin this Alternative must be timely. Sufficient time must have elapsed to indicate that the outbreak is persisting, in spite of natural controls. Earlier treatment would not have prevented the "spread" of budworm infestation. The application of *B.t.* should have no effect on future outbreaks. The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of vigorous populations.

Chapter 3:
Affected Environment

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CHAPTER III. AFFECTED ENVIRONMENT

Introduction

Area Affected

Chapter III describes the environment that would be affected by implementation of any of the Alternatives. The environmental factors discussed are those which are significant and pertinent to identified Issues and concerns, including the relevant physical, biological, economic, and social factors. This chapter describes the interaction of the resources, protective environmental considerations, commodity output, potential output, and changes and trends. It also provides basic information relating to the Issues and concerns.

Location

The Pacific Northwest Region (Region 6) includes the States of Oregon and Washington, as well as small portions of northern California and western Idaho. The Region encompasses a total area of 106 million acres. The USDA Forest Service administers 24.5 million acres. The Forest Service also assists in the protection and management of 20.5 million acres of other commercial forest lands through cooperative programs with private and corporate landowners, as well as State and local governments. Much of this ownership is an intermingled, checkerboard pattern of ownership.

Water Quality/Quantity

The National Forests occupy 23 percent of the land in the Pacific Northwest, yet 44 percent of the region's water supply originates on National Forest land. There are 112,000 miles of streams and approximately 216,000 surface acres of lakes and reservoirs which provide 75 million acre-feet of water. There are thousands of acres of wetlands and floodplains which provide unusually diverse habitat, particularly where riparian and terrestrial ecosystems meet.

About 6 million acres, approximately one-quarter of National Forest lands, are administered as domestic watersheds. About 800,000 acres are managed under formal agreements with 15 municipalities. Many of the agreements list specific restrictions. For example, the cities of Ashland, Medford, Portland, Seattle, and The Dalles prohibit or severely restrict the use of pesticides. There are approximately 60 additional watersheds which are maintained for individual use; ski areas, etc. These are not managed under formal agreements. Other uses include irrigation, hydroelectric generation, and fish production.

The quality and quantity of water provided by the National Forests are dependent on judicious management of vegetation and soils in each watershed. Managing streamside vegetation, roadside vegetation (particularly during and shortly after road construction), and vegetation affected by timber harvest is key to maintaining water quality.

Sediment is the primary polluting factor reducing water quality. Soil erosion caused by road construction, timber harvest, landslides, and natural sloughing of streambanks is the major source of sedimentation.

Water quality in National Forest streams is generally excellent. For example, water from the Bull Run watershed, which supplies the city of Portland, requires little treatment.

Federal agencies with responsibilities involving water resources include the Environmental Protection Agency, Army Corps of Engineers, United States Geological Survey, and the Soil Conservation Service.

Washington State agencies include the Washington Department of Game, Washington Department of Ecology, Washington Department of Fisheries, and the Washington Department of Natural Resources.

Oregon State agencies include the Oregon Department of Environmental Quality, Oregon Department of Forestry, Oregon Water Resources Department, Oregon Department of Lands, and the Oregon Department of Fish and Wildlife.

The North Coast Regional Water Quality Control Board (California) and the California Department of

Fish and Game are also involved with management of water resources in the Region.

Fire And Fuels

Fire, or the absence of fire, is a significant factor in the development and natural succession of forest plant communities. Throughout the Pacific Norhtwest generally, but east of the Cascade Mountains especially, naturally recurring fire 'cycles' served to determine the species of trees and other plants which appear in the many distinct ecosystems of the Region.

Prior to the arrival of European immigrants in the Pacific Northwest, lightning fires burned unchecked. Native Americans used fire to clear berryfields of thick underbrush. Some areas of undergrowth were systematically burned every 3 to 5 years. These natural and Native-caused fires burned at frequent intervals (3-25 years) in the grass and ponderosa pine regions, but less frequently (100-300 years) through mixed conifer stands. Catastrophic fires, such as those that naturally occurred in lodgepole pine regions every 80-120 years, would entirely replace existing stands of timber.

Settlers discouraged the use of fire as a way to manipulate vegetation, seeing it purely as a menace and a threat. The savanna-like pine stands, previously kept clear of underbrush by wildfire or intentional burning, grew more dense with vegetation in the absence of fire. This natural encroachment changed the characteristics of the environment.

An aggressive fire suppression policy has been followed throughout the history of National Forest management. Immediate control actions are generally taken on all unplanned ignitions. This policy of fire suppression has resulted in some unexpected effects. Fuel accumulations have increased to unprecedented levels in some areas, and tree species composition and associated plant communities are also changed.

Before 1900, portions of the forests burned periodically, especially in the more flammable pine stands. Since fire suppression programs were initiated in the early 1900's, the resulting break in natural fire cycles has changed the environment to one more favorable to fire-sensitive fir and other plant species. A study of fire ecology in the Blue Mountains of eastern Oregon has shown that white fir and Douglas-fir plant communities have gradually replaced the more fire resistant ponderosa pine communities (Hall, 1977).

Fire plays an important role in the evolution of ecosystems. Periodic fire is essential in perpetuating many plant communities found in the Blue Mountains of eastern Oregon and southeast Washington (Hall, 1977). Fire scars indicate that fires of varying intensities would occur on the average of once every ten years prior to fire protection. High intensity fires allowed plant communities dominated by highly competitive lodgepole pine and western larch to be favored over ponderosa pine; while low intensity surface fires maintained open, park-like stands of mature ponderosa pine and larch.

Surface fires were a common occurrence in ponderosa pine regions before the advent of forest management. Occurring at 5- to 25-year intervals at the lower elevations, these were usually low intensity fires which burned accumulations of forest litter and light brush. Fires like these caused a reduction in fuel loading and the removal fire-sensitive tree species. The thick-barked pines thrived under this regime. Competing vegetation was effectively controlled and a seed bed was provided for the light-demanding pine seedlings. As a result of fire suppression, shade-tolerant species of trees now grow under the pines and may eventually replace them.

Catastrophic fires with long intervals between them produced the large stands of old-growth Douglas-fir west of the Cascades in the western hemlock zone. Fires in the mixed conifer and true fir zones also tend to be intense, stand-replacing burns. Post-fire succession is less well understood in these stands. A mixture of species often resulted from fires which occurred in these zones. Before modern fire protection efforts began, fires occurred infrequently, but often with high intensity. Ecological studies show these stand-replacing fires occurred at intervals of about 150 years at lower elevations on the west slope of the Cascades, and at 300- to 1,000-year intervals in higher elevations along the Cascade Crest.

Due to fire suppression and exclusion policies of the past 80 years, the natural ecological cycles involving nutrients, energy, and vegetation dynamics have been altered. Timber harvest and site preparation activities have, to some degree, assumed fire's ecological role of eliminating woody fuels. Grazing has changed vegetation types in other areas, by removing fuels such as grasses, forbs, and succulent brush species. Neither timber harvest nor grazing can exactly replicate past fire effects though. And as a result, the open stands of stately pine are being replaced by a mosaic of closed canopy, multistoried stands that cover large areas of the forest. These stands are highly flammable. The open pine stands of the past were maintained by naturally recurring fire events (Hall, 1976; Volland and Dell, 1981).

The greatest fire hazards on Pacific Northwest forests are in:

1. Areas of fuel created from insect-caused mortality;

2. Stands at higher elevations where there is historically a high density of lightning strikes;

3. Logging slash and precommercial thinning slash;

4. Areas containing high rate-of-spread fuels, grass, and shrubs.

Many years of effective fire suppression has caused unnatural accumulations of needle litter, dead limbs, and dead trees; any one of which can lead to high intensity, damaging wildfires. Outbreaks of mountain pine beetle, western spruce budworm, and Douglas-fir tussock moth have added, or are adding to accumulated fuels.

Natural fuels in the forest are a result of natural processes, and have increased dramatically in recent years. Insect infestations, especially of the mountain pine beetle, are a primary cause. Prescribed burning or other treatment of natural fuels has so far received very little emphasis in management plans. As a result, fuels have accumulated to levels well beyond the 'natural' condition in many areas. Large and destructive wildfires may be an unavoidable effect.

Soils

Soils take on many of the characteristics of the rock from which they are formed. For example, serpentinites in the Wallowa-Whitman, Wenatchee, and Siskiyou National Forests produce nutritionally unbalanced, unproductive, and unstable soils. Ash and pumice deposits from the eruptions of Mount Mazama (which created Crater Lake), and more recently from Mount St. Helens, offer more nutritional balance than serpentinites, but are relatively sterile and erodible.

Soil texture and surface conditions are related to soil porosity, infiltration, and percolation rates. These variables contribute to the chemical disposition of soil systems and site productivity as well. Generally, chemical analyses must be performed on a site-specific basis. Few characteristics are common throughout the region. Granitic materials and sandstones, however, are often very coarse and porous.

Soil depth, texture, and productivity vary throughout the region. Some of the deepest, most productive forest soils are found in the lower and gentler slopes of the Cascade and Coastal forests below the 2,000-foot elevation.

Climate

Winter storms and the summer Pacific high pressure area are dominant regional climatic features. The winters are notably wet (typically 80 percent of the total annual precipitation falls in winter), and the dry summers are inconsistently interrupted by localized thunderstorms, particularly in the Transition and East-side forests.

High rainfall (over 150 inches at the coastal crest), and summer fog keep the Coastal forests wet most of the year. Temperatures are moderate. Freezing temperatures and snow are experienced only during midwinter.

Cascade forests receive from about 100 inches of annual precipitation on the Rogue River and Umpqua National Forests, to over 150 inches on the Gifford Pinchot and Mt. Baker-Snoqualmie National Forests. Snowpacks last well into summer, feeding many permanent streams. Late spring frost is common.

The rain shadow produced by the Cascades reduces the annual rainfall significantly in the Transition forests. Because the moderating marine influence wanes at the Cascade Crest, average annual temperatures can be 10 degrees Fahrenheit lower there than on Cascade sites.

Precipitation on the East-side forests is less than 20 inches annually in some areas. However, most of the forests are located on mountain ranges or uplands (the Wallowa Mountains, the Blue Mountains, and the Okanogan Highlands), and precipitation increases with elevation, as does the potential for summer lightning storms. Summers are hot and dry. Frost can occur any time of year.

Vegetation

Plant Communities

All true fir and Douglas-fir stands are potential hosts for western spruce budworm. The current outbreak is located primarily on the east side of the Cascade Mountain Range. Discussion of vegetation will primarily focus on that area, although the West-side true fir and Douglas-fir stands will also be discussed.

Forest ecosystems are in a constant state of change. The process whereby one type of plant community replaces another without catastrophic disturbance is

called succession. Plant communities are composed of several different layers of vegetation; trees in the upper and lower canopy, a brush and shrub layer, and a grass and forb layer. All the different plants in these layers have a relationship to and effect on the ecosystem.

In the temperate coniferous forest ecosystem a forest which began as an even-aged stand of a pioneer species, such as aspen or lodgepole, changes to an uneven-aged forest of various conifer species, primarily Douglas-fir and grand or white fir, as a result of natural succession. Examples of intermediate species in this succession are ponderosa pine and western larch.

Fire is a catastrophic disturbance which interrupts succession, and has played a distinct role in the ecosystem development of the forests. In the ponderosa pine timber types, vegetation has evolved to accommodate a fire ecology. The park-like stands of ponderosa pine and their open, grassy understory were maintained, in great part, by fire.

There are two types of fires which produce different results: high intensity conflagration fires and low intensity ground fires.

In East-side forest plant communities, areas subjected to high intensity fires in the past are now dominated by western larch, lodgepole pine, or a western larch/fir mixture. West-side stands, following conflagration fire histories, are Douglas-fir, true fir, and hemlock communities. In the latter, fires would usually occur on northerly or easterly slopes. Because of higher moisture retention, fuels on these slopes were not as susceptible to low intensity ground fires and did not burn often. These fuels built up over time until a drought year combined with a natural or human-caused ignition. On the west side of the Cascades, high intensity fire frequency ranged from every 50 to 300 years. High intensity fires probably did not occur more than once every 15 to 25 years on the east side of the Cascades. In both cases, the fires were devastating to large acreages of forest and range.

Low intensity ground fires produced a totally different effect in the forest environment. This type of fire normally occurred in the ponderosa pine plant community. Based on fire scars in ponderosa pine, it is estimated that low intensity fires occurred on an average of once every 10 years. These fires resulted in nonselective thinning of young ponderosa pine, selective elimination of white fir and Douglas-fir, and maintained a rather open spacing of trees.

The vegetative composition of National Forests has changed greatly during the last century. These changes are especially evident on the East-side Forests. Heavy grazing by horses, sheep, and cattle around the turn of the century tended to increase the early stages of forbs and grasses. Aggressive fire prevention and suppression practices over the past 80 years have helped convert open grasslands to tree-growing sites, and open pine stands to thickets of mixed conifer species. In other areas, the late seral stages of tree species were greatly increased in the 1950's and 1960's by logging practices which selectively removed the ponderosa pine.

The change in species composition from ponderosa pine to white fir or Douglas-fir is accompanied by increased susceptibility to insects and disease. Insects and disease are not new to the forests, but as their host types increase, the potential for their occurrence also increases.

Timber

Much of the land within the National Forests of the Pacific Northwest Region is among the most productive forest land in the world, Table III-I. Roughly 90 percent of National Forest lands are forested. Of this, approximately 76 percent (18.5 million acres) has a productivity level equal to or exceeding 20 cubic feet of wood growth per acre per year. Timberlands have traditionally been divided into two broad subregions: the Coastal and Western Cascades subregion and the East-side and Transition subregion.

Demand for timber varies with market and economic conditions, and is affected by short-term decisions of other agencies and industrial ownerships. As a general rule though, there are purchasers for all timber volumes made available for harvest. Sale of National Forest timber tends to fluctuate on an annual basis, in accord with administrative and budget priorities.

Recent trends in timber harvest levels and the acreage which has been made available for harvest are reflected in Forest land management planning processes. While conditions vary from Forest to Forest, the general trend indicates that programmed harvest levels will diminish from what they have been in the recent past. (It has been estimated that the Region's annual timber harvest (Allowable Sale Quantity) will be in the range of 3.8 to 4.3 billion board feet in the years following implementation of the 19 Forest land management plans.)

Additions to the Wilderness System, allocations to protect sensitive resources, and recent cost analyses have reduced the amount of timberland in the "base". Programmed harvest levels reflect this. Harvest of timber from all Forests, however, will continue to be a valuable and significant activity, Table III-II.

TABLE III-I

Timber Productivity on Available Commercial Forest Lands in the Pacific Northwest Region
(Cubic Feet per Acre per Year)

	Productivity Class				
	120+	85-119	50-84	20-49	TOTAL
Coastal and Western Cascades subregion					
Thousand Acres	2,825	1,552	1,991	290	6,658
Percent	43	23	30	4	100
East-side and Transition subregion					
Thousand Acres	655	2,148	5,399	1,660	9,862
Percent	7	22	55	16	100
Total Region					
Thousand Acres	3,480	3,700	7,390	1,950	16,520
Percent	21	22	45	12	100

Source: Regional Guide for the Pacific Northwest Region, 1984, USDA Forest Service.

TABLE III-II

Standing Softwood Volumes
--based on International 1/4-inch Scale--
on Commercial Forest Lands of the Pacific Northwest Region

	Million Board Feet	Percent
Coastal and Western Cascades subregion	270,508	70
East-side and Transition subregion	115,944	30
Total	386,452	100

Source: Regional Guide for the Pacific Northwest Region, 1984, USDA Forest Service.

In some situations, the removal of forest trees is done to facilitate habitat enhancement, to meet visual quality objectives, or to provide for fire protection. Timber yields in these special instances are byproducts of projects intended to enhance other resource values.

Programmed timber harvest though, typically results in manipulation of forest density and species composition, horizontal or vertical (spatial) distribution, and changes in local vegetation. Any of

these environmental changes may cause an increase in western spruce budworm 'host type' species.

The increase in host type, however, is not the only causal factor in the current western spruce budworm outbreak. While most of the stands of white fir and Douglas-fir in affected areas have been suppressed by a ponderosa pine overstory in the past, removal of the pine has opened the canopy to a dense and slow growing understory. The poor health of these stands, compounded by the present drought cycle, has resulted in thousands of acres of susceptible but unviable host trees.

The characteristics of site and stand that most effect susceptibility to budworm have been described as follows (Wulf and Cates, 1985):

Regional climate—General climate significantly affects budworm dynamics. Climate tends to be cool and moist where outbreak frequency is low, but warm and dry where outbreak frequency is high (Kemp, 1983).

Site climate—Given that the regional climate is favorable to budworm, stands on warm, dry sites are the most susceptible. Warm, dry conditions accelerate larval development and tend to stress host trees.

Species composition—Stands composed primarily of host species are more susceptible than mixed stands because more food is available to developing larvae and more sites are present for egg deposition. Furthermore, stands composed primarily of host species that are shade-tolerant tend to be more susceptible than stands that have a sizable component of shade-intolerant host species.

Stand density—Dense host stands are more susceptible than relatively open stands because of increased foliar biomass and increased water and nutrient stress.

Height Class structure—Multistoried stands are more susceptible than single-storied, even-aged stands. In the former, cover provided to the lower stories significantly reduces the mortality of dispersing larvae and provides additional substrate.

Vigor—Stressed stands tend to be more susceptible; and we believe the quality of the foliage as insect food is enhanced. Low-vigor stands tend to have an altered terpene regime that apparently weakens tree resistance.

Maturity—Older, mature host stands tend to be more susceptible than young stands.

Surrounding host type—Stands in close proximity to forests composed of host species tend to be more susceptible than relatively isolated stands. The probability of adult or larval invasion is much higher when large numbers of a suitable host trees are nearby.

Insect-caused tree mortality on the forests has been heavy during the past 20 years. Primary causal agents have been Douglas-fir tussock moth, mountain pine beetle, and western spruce budworm. Currently, western spruce budworm and mountain pine beetle are causing the largest amount of mortality.

Threatened, Endangered, and Sensitive Plant Species

Only one plant species currently listed under the Endangered Species Act is known to occur on National Forest lands in Oregon and Washington. MacFarlane's Four-o'clock (*Mirabilis macfarlane*) is listed as Endangered. It is known to occur on only a few locations in the Snake River country of Oregon and Idaho. When a listed species may be affected by planned Forest Service activities, the U.S. Fish and Wildlife Service is consulted. Every effort is then made to ensure that activities will not jeopardize the continued survival of the species.

More than four hundred plant species are currently included on the Regional Forester's list of sensitive species. Others, not yet on that list, are being considered for inclusion. All of these species are recognized as Endangered, Threatened, or Sensitive by the States of Oregon and Washington; and/or are under review by the U.S. Fish and Wildlife Service.

These species include the full range of vascular plants, from grapeferns and club mosses to orchids and grasses. They occupy a wide variety of habitat. Often they occur in less common habitat areas such as in wetlands, riparian zones, rock outcropings, or in soils derived from unusual parent material, such as serpentine. Sensitive plant species can be found throughout the region. Particularly high concentrations are known to occur in the Siskiyou, Wenatchee and Wallowa mountain ranges, and in the Columbia River Gorge.

A full biological evaluation always precedes Forest Service projects which might disturb these species or their habitat (Forest Service Manual, 2670). This process is designed to determine if sensitive species or their habitat are present in the project area, and if so, whether or not implementation would cause adverse biological effects. Mitigation measures or project modification(s) may then be planned, as appropriate.

Riparian Vegetation

Riparian vegetation includes any nonaquatic vegetation that directly influences the stream environment. The riparian zone is the area bordering streams, lakes, and wetlands. It is the transitional environment between aquatic and upland zones.

Riparian plant communities may be dominated by:

1. Herbaceous species (mainly rushes, sedges, and grasses);

2. Hardwood species (mostly alder, bigleaf maple, willows, Oregon ash, or black cottonwood);

3. Coniferous species (western hemlock, Sitka spruce, western redcedar or lodgepole).

There are approximately 775,000 acres of riparian areas within National Forest lands in the Pacific Northwest Region. Riparian areas constitute 1 to 6 percent of the suitable timberlands on East-side Forests, and 3 to 14 percent of the timberlands on West-side Forests.

While riparian areas occupy only a small part of the overall land base in the Region, they are a critical source of diversity within forest ecosystems. They create distinct habitat zones within the drier surrounding areas.

Riparian vegetation provides a source of food, cover, shade, and woody debris for fish and wildlife. Vegetation growing along stream banks helps to stabilize the banks and create habitat for fish. The litter layer serves to filter sediment transported from upland areas by surface erosion. Riparian areas are also highly productive sites for timber and forage.

The Forest Service is mandated to protect riparian areas. No management activities that will cause detrimental changes in water quality, block water courses, or deposit sediment which will seriously and adversely affect water or fish, are permitted within riparian areas.

Forest Insects

Protection of the Forests from damage is a goal of the Forest Service. Among natural destructive agents, insects rank with fire, disease, and wind in their potential for damaging Forest resources. Before humans entered the forests of the northern interior west, climatic and geological events, insects, disease, animals, and fire interacted with each other, and with vegetation, to influence forest development.

Silvicultural measures are available for managing some of the diseases on the Forests. The most practicable means of managing most diseases though, are: removal of infected trees, cultural activities that improve tree vigor, cultivation of less susceptible tree species, and enforcement of practices that reduce the probability of mechanical damage. Disease and insect-caused losses are expected to be reduced over time as timber stands are replaced by healthy, young, mixed tree species.

Insects and disease, as well as fire, perform natural roles in the the life of forests. Under normal endemic conditions, insects play a vital role in a system of natural balances.

Most western forest insects are native, and their populations are widely distributed. Their role is complex. Their effect may be either beneficent or harmful. The beneficial and innocuous insects are, by far, the most abundant. Destructive insects receive the most attention because they affect the human environment most directly (Furniss and Carolin, 1977).

Diseases also have a place in altering stand composition. They discriminate against some tree species and thereby allow other species become established. Most diseases are opportunistic, taking advantage of the right environmental situation to gain a foothold in the host and perpetuate themselves by seeds or spores. Infection of wounds by microorganisms is a major cause of defect, death, and decay of all species of trees.

Many times damage by one pest will create situations so favorable to another that more serious damage will result from the second pest. Defoliators, for example, often cause varying degrees of crown defoliation: dead lateral branch tips, dead tops, stem deformity, and loss of radial and height growth for a few years. Mortality though, is an exception rather than the rule. Generally, the more serious consequences of defoliation are subsequent deadly attacks of bark beetles. Dead tissue also becomes an entry point for stem rots. Bark beetle attacks in lodgepole and ponderosa pine may not be severe enough to kill the tree, but may introduce blue stain fungus. Death of a tree from root rot may progress slowly, but the weakened tree may attract enough bark beetles to cause its death within a couple of months. Pockets of beetle-killed timber are usually centers for root rot infestation; which in turn will attract more bark beetles to the weakened trees. Diseased, defoliated, injured, or otherwise unhealthy trees emit a chemical odor which attracts bark beetles. After a certain number of beetles have already entered a tree, subsequent populations will attack nearby healthy trees.

Forest insects and diseases cause the loss of more timber in the United States annually than fires do. During the past 15 years, the East-side forests have been impacted by the Douglas-fir tussock moth (*Orgyia pseudotsugata*), mountain pine beetle (*Dendroctonus ponderosae*), western spruce budworm (*Choristoneura occidentalis*), and larch casebearer (*Coleophore laricella*). These attacks have been followed by more mortality caused by Douglas-fir

bark beetle and the fir engraver beetle; and the less spectacular losses associated with the western pine beetle, Ips beetle, western dwarf mistletoe, and stem and root diseases.

Douglas-fir Tussock Moth

The Douglas-fir tussock moth, *Orgyia pseudotsugata*, is a significant defoliator of true firs and Douglas-fir in western North America. The common name of this insect, "tussock moth", is derived from the brush-like body hairs on the larvae. Damage to the host is caused by the feeding of the larvae, first on the new foliage and then on old. Defoliation occurs first in the tops of trees and branch tips, and then in the lower crown and further back on the branches. As defoliation progresses the trees become brown, due to the exposure of twigs and branches.

Defoliation by the tussock moth kills or top-kills some trees, weakens others and allows for bark beetle-kill; or will often simply retard tree growth for several years. A very large tussock moth outbreak in Oregon and Washington recently killed 39 percent of all trees in the heavily defoliated areas. Within these areas were patches where nearly all the trees died. Top-kill in the heavily defoliated areas amounted to 10 percent of the grand fir and 35 percent of the Douglas-fir.

Although the tussock moth is no longer abundant, the legacy of the epidemic is still visible. Severe defoliation resulted in widespread top-kill and large numbers of dead trees. Many trees that were not initially killed by the tussock moth were later killed by bark beetles.

The Douglas-fir tussock moth and the western spruce budworm are both defoliators whose numbers periodically reach epidemic proportions. These insects require a common set of host species. The combined effect of stressed and weakened tussock/budworm host trees is a primary causal agent in bark beetle epidemics.

Mountain Pine Beetle

Dendroctonus (meaning tree killer) beetles, particularly the mountain pine beetle, have been dramatic mortality agents in the forests. In 1968 a mountain pine beetle epidemic on the Wallowa-Whitman Forest in eastern Oregon was identified. The outbreak had been fueled by large stands of over-mature, overstocked, and stagnated lodgepole pine. Harvest of trees in affected areas, followed by prompt regeneration was the preferred method of handling the infestation. The harvest program is expected to decline in the next 5 to 10 years as remnant trees in areas of the infestations deteriorate beyond salvageable value.

Western spruce budworm occasionally feed on or are associated with a variety of western pines. Defoliation of these species by the spruce budworm is generally insignificant.

Douglas-fir Beetle

The Douglas-fir beetle, *Dendroctonus pseudotsugae*, is the most important bark beetle pest of Douglas-fir throughout the range of this tree in the western United States, British Columbia, and Mexico. It also attacks western larch. Endemic populations of beetles normally attack and kill small groups of trees which are diseased, injured, or have been felled. At times, epidemic populations develop in abundant susceptible hosts and then spread to adjacent green, apparently healthy trees. These epidemics usually develop following extensive natural or human-caused disturbances such as windthrow, fire, defoliation, drought, or widespread cutting.

There is a direct relationship between beetle infestations and outbreaks of defoliating insects. Following some Douglas-fir tussock moth or western spruce budworm infestations there has been a corresponding increase of bark beetle activity.

Larch Casebearer

The larch casebearer is a European insect that became established in New England prior to 1886. In the West it was discovered on western larch in northern Idaho in 1956. Principal damage is caused by the larvae feeding on new foliage in early spring. Repeated defoliation for several years reduces diameter growth and weakens trees so that they may die from other causes (Furniss and Carolin, 1977).

The larch casebearer and the western spruce budworm are defoliators which exhibit sporadic periods of infestation. They feed primarily on the same host species. The combined effect of their stressed and weakened host trees is a typical causal agent in bark beetle epidemics.

Miscellaneous Forest Insects

Other insects that cause mortality or disrupt management opportunities are the pine butterfly (*Neophasia menapia*), fir engraver (*Scolytus ventralis*), pine engraver (*Ips pini*), and the western pine beetle (*Dendroctonus brevicomis*).

Forest Diseases

Laminated root rot (*Phellinus weirii*), shoestring root rot (*Armillaria mellea*), and brown root or butt rot (*Fomes annosus*) are the most significant root rots causing localized mortality. Their proliferation may affect future management of young stands. Fungi which promote decay, such as *Fomes annosus*, may cause substantial loss of volume if trees are wounded during logging. Brown stringy rot (*Echinodontium tinctorium*), a significant heart rot, commonly infects grand fir, white fir, and subalpine fir; causing significant defect in overmature timber stands. Dwarf mistletoe (*Arceuthobium sp.*) infects Douglas-fir, western larch, lodgepole pine, and ponderosa pine. This parasitic plant weakens trees, causes deformity, and reduces growth.

Laminated Root Rot

Laminated root rot, caused by the fungus *Phellinus weirii*, is the most damaging disease to Douglas-fir in the Pacific Northwest, causing growth loss and eventual death in most trees it infects. It is responsible for an estimated annual loss of 32 million cubic feet of timber in western Oregon and Washington. The magnitude of loss on interior, mixed conifer stands is estimated to be about 40 percent of total mortality; based on preliminary surveys conducted on the Fremont and Ochoco National Forests (Schmitt, C.L., et al.). This disease can infect all conifers, but some tolerate the pathogen better than others. Those trees readily infected and killed (highly susceptible) are Douglas-fir, mountain hemlock, white fir, and grand fir. Often infected but rarely killed (intermediately susceptible), are western hemlock, western larch, Pacific silver fir, subalpine fir, California red fir, and the spruces. Seldom infected and almost never killed (tolerant or resistant) are the pines and cedars.

Phellinus weirii extensively decays roots of highly susceptible host trees. Mortality will usually result from windthrow or the trees' decreased ability to take up water and nutrients. Trees which are also under stress by spruce budworm defoliation are more susceptible to mortality by Phellinus than nonhost species. In addition, these trees are predisposed to bark beetle attack.

Armillaria

Armillaria root disease in conifers, caused by the fungus *Armillaria obscura*, is the most common and widely distributed forest root disease in Oregon and Washington. All conifers can be damaged by this disease, but there are differences in degree of susceptibility and damage expression.

In forests east of the Cascade crest, plantation damage caused by Armillaria root disease becomes apparent at 5 years. It may then continue throughout the life of the stand. Habitat type has been found to influence the presence of Armillaria root disease in northern Idaho and eastern Oregon and Washington. The fungus is nearly always present in plots established in cool and moist to warm and moist sites. It does not appear on cold and dry, hot and dry, or frost-pocket sites. Armillaria root disease is less likely to be found on high-productivity sites; of the grand fir, western redcedar, and western hemlock climax series, than it is on low-productivity sites; of the subalpine fir and Douglas-fir climax series. Douglas-fir, grand fir, and subalpine fir show the highest levels of infection where they are the climax species. The probability of finding pathogenic Armillaria on the high-productivity habitat types was found to be higher where human-caused disturbance had been effected than on undisturbed plots.

Tree mortality is the most common form of damage caused by Armillaria root disease. Affected trees can be windthrown, but tend to die standing. Various species of bark beetles, particularly fir engravers (*Scolytus ventralis*) in white fir and grand fir, will attack trees weakened by Armillaria root disease and may hasten mortality. Mortality caused by Armillaria root disease will often increase 1 to 2 years after severe droughts or nearly complete defoliation by insects. *A. obscura* is able to break out of callus tissues on roots and spread rapidly when trees are severely stressed or when they are cut.

Armillaria root disease centers develop when neighboring trees are infected and killed over many years. Expansion rates probably average 1 foot per year, but may be 2 to 3 feet in some stands. Disease centers often contain infected old-growth stumps, the original source of infection; and trees in several stages of deterioration. Fortunately, some disease centers become inactive and damage subsides.

In addition to tree mortality, Armillaria root disease can cause butt rot and reduction of growth. If a tree is not directly killed, a compartmentalized root and butt rot may occur, especially in nonresinous conifers such as hemlock and true firs. The amount of bark killing and associated internal decay are dependent on innoculum potential, tree vigor, tree age, tree species, and host genetics.

Fomes annosus

Annosus root and butt rot is caused by the fungus *Fomes annosus*. Mortality, susceptibility to windthrow, and slowing of growth are its effects.

All conifers can be infected by *F. annosus*, but there are differences in susceptablilty and degree of damage among the affected species. In the Pacific Northwest western hemlock, mountain hemlock, grand fir, white fir, and Pacific silver fir are highly susceptible to infection and can be severely damaged. Ponderosa pine, lodgepole pine, noble fir, subalpine fir, and California red fir are moderately susceptible and sometimes damaged. Douglas-fir, western redcedar, incense cedar, Port Orford cedar, western larch, western white pine, sugar pine, Englemann spruce, and Sitka spruce are slightly susceptible and rarely damaged. Hardwoods are not affected. Apparently, different strains of *F. annosus* have rather specific host preferences. There is strong evidence, for example, that the fungus will not spread from white fir stumps to ponderosa pine and vice versa.

Fomes annosus causes tree mortality and wood loss through decay. Tree death is the usual result of infection in resinous hosts and in white fir and grand fir in southeastern Oregon. Trees killed by annosus root disease tend to die standing rather than be windthrown. Mountain pine beetles (*Dendroctonus ponderosae*) and western pine beetles (*D. brevicomis*) often attack infected pines; and attacks by fir engraver (*Scolytus ventralis*) are common on infected true firs. Armillaria root disease is also frequently found on trees infected by *F. annosus*.

Hemlocks are much more likely to suffer butt decay than to be killed by *F. annosus*. Most decay will be associated with wounds and will be confined to woody tissues present when the trees were wounded. Losses due to annosus butt decay in hemlock stands tend to be small unless trees are older than 120 years or have been badly wounded.

Indian Paint Fungus

Indian paint fungus, or brown stringy rot, caused by *Echinodontium tinctorium*, is responsible for nearly 80 percent of the decay in old-growth grand fir stands in eastern Oregon and Washington. Cull material, primarily caused by decay, approached 40 percent of the total board-foot volume in mature and overmature grand fir in the Blue Mountains of Oregon. True firs and hemlock are the primary hosts of this disease; Douglas-fir and spruce are rarely infected.

Brown stringy rot is most common in the mid-trunk region, but may extend into the butt or down from the top. Stands of advanced regeneration may suffer significant volume loss to the decay which results from mechanical damage.

Wildlife

Forests of the Pacific Northwest Region are known to provide habitat for 569 species of resident and migratory, terrestrial vertebrate wildlife (174 mammals, 335 birds, and 60 reptiles and amphibians). Lists of species and habitat relationships can be found in Thomas (1979), Thomas and Maser (1983), and Brown (1985).

Public demand for wildlife resources is measured by consumptive (hunting) and nonconsumptive (viewing) uses. Wildlife and Fish User Days (WFUD's) are used to measure the demand for these resources. The most recent summary of public demand (Annual Fish and Wildlife Report, 1984), shows that 8.3 million WFUD's were attributed to the wildlife resource.

In order to maintain viable, self-sustaining populations of wildlife, an appropriate amount and distribution of suitable habitat must exist. The amount and distribution of habitat will vary over time. Changes in habitat condition and suitability can occur abruptly (as the result of fire, windstorm, or timber harvest), or more gradually (as in the slow replacement of plant communities characteristic of succession).

On forested sites, six different successional stages (or stand conditions) are usually recognized: grass-forb, shrub, open sapling-pole, closed sapling-pole, mature, and old growth (Brown, 1985). Each successional stage in each forest plant community supports a characteristic grouping of wildlife species.

Some species find suitable habitat in a wide variety of plant communities and stand conditions, while others favor specific plant communities and stand conditions. Species with specific habitat requirements are generally less tolerant to changes in vegetation.

Deer and elk use many plant communities—shrub through old-growth successional stages—for hiding and/or thermal cover. Depending on environmental conditions and forage availability, they feed in a wide variety of plant communities and stand conditions. These species are relatively tolerant of changes in habitat conditions.

The western red-backed vole and northern spotted owl are dependent upon older, closed-canopy forest stands. These species are sensitive to changes in stand conditions. Their population levels could drop dramatically as stands are converted to younger age classes.

In the absence of human manipulation, natural landscapes support characteristic patterns of plant communities and stand conditions. These reflect, in part, the frequency of disturbances, site productivity, and successional changes that occur over time.

Most forested sites historically experienced stand-replacing fires at intervals of several hundred years. The long intervals between such events, combined with the longevity of trees such as Douglas-fir and the fire resistance of such trees as oak and ponderosa pine, led to a landscape comprised largely of mature and old-growth stands (Harris 1984).

As a result of clearing, logging, and wildfire, much of the forest land in Oregon and Washington is currently occupied by younger timber stands. Some wildlife populations will increase as forested lands return to early successional stages, and those that thrive in older forests will decline.

Management of wildlife populations involves a partnership between State and Federal agencies. The Pacific Northwest Region has drafted Memoranda of Understanding with the Oregon Department of Fish and Wildlife and the Washington Department of Game, to facilitate the development of common goals and management strategies for the wildlife resource. These agreements provide opportunities for cooperative interagency planning, funding, and implementation of projects designed to benefit wildlife populations.

Wildlife distribution and abundance are influenced by vegetation, but animals can also affect the distribution and abundance of vegetation. Animals can carry and distribute seeds, and so determine where plants grow. Grazing and browsing by wildlife can affect plant growth and vigor, including that of young trees.

Many wildlife species including bear, deer, elk, mountain beaver, porcupine, hares, rabbits, and various small rodents can have adverse effects on the survival and growth of conifers. Conversely, wildlife may browse vegetation that competes with conifer seedlings, and foraging by many bird species may provide natural control of insects which damage many conifer stands. Animals also play a vital role in dispersing spores of certain fungi which are essential to tree growth (Maser, et al., 1978).

Threatened, Endangered, and Sensitive Animal Species

Six wildlife species currently listed by the U.S. Fish and Wildlife Service as Endangered or Threatened under the Endangered Species Act are known to occur or suspected to occur on National Forest lands in the Pacific Northwest. These species and their status are listed in Table III-III.

These species differ widely in their distribution in the Northwest. The brown pelican has been sighted in coastal areas of the Siuslaw National Forest. Woodland caribou occur only on the Colville National Forest. In the State of Washington, sightings of grizzly bear and gray wolf have been documented in four and five Forests, respectively. Peregrine falcons are known to occur or are suspected to occur on all but three National Forests in the Region. The bald eagle is known to have nesting, winter roosting, or migratory sites on all 19 Forests.

Thirty-six other species (8 mammals, 14 birds, 1 reptile, 3 amphibians, and 10 fish) are included on the Regional list of Sensitive species. This list includes species considered by the States of Oregon and/or Washington to be Threatened or Endangered. These species are under review by the U.S. Fish and Wildlife Service.

The northern spotted owl (Strix occidentalis) is a sensitive species of special public concern that occurs within the area considered by this EIS. The owl is expected to be found in mature old growth forests primarily on the west side of the Cascades. The U.S. Fish and Wildlife Service has recently proposed that the northern spotted owl be considered for listing as a Threatened species.

The Forest Service cooperates with other Federal agencies and State wildlife agencies in efforts to protect and improve habitat requirements for these species. Cooperative efforts to reintroduce some of these species into portions of their former ranges are also underway.

Fisheries

The Pacific Northwest Region has approximately 15,000 miles of streams that directly support both resident and anadromous fish. There are approximately 150,000 acres of lakes and 65,000 acres of reservoirs that can support both warm and cold water species of fish. These aquatic habitats range from estuaries on the Siuslaw National Forest to alpine lakes along the Cascade Crest.

Resident game fish include rainbow, eastern brook, Dolly Varden, and cutthroat trout; crappie; bluegill; yellow perch; smallmouth and largemouth bass; Kokanee; and mountain whitefish. All are highly valued by recreational anglers.

TABLE III-III

Threatened and Endangered Wildlife Species

Gray wolf *Canis lupus*	E
Grizzly bear *Ursus arctos*	T
Woodland caribou *Rangifer tarandus californiana*	E
Brown pelican *Pelecanus occidentalis*	E
Northern bald eagle *Haliaetus leucocephalus*	T
American peregrine falcon *Falco peregrinus anatum*	E

T = Threatened

E = Endangered

Anadromous fish (fish that spawn in fresh water and migrate to the ocean to mature) have both sport and commercial value. They are found on 15 of the 19 National Forests in the Region. Pink, chum, coho, sockeye, and chinook salmon; and steelhead and sea-run cutthroat trout depend on streams in the Region for spawning and rearing habitat.

The Pacific Northwest Region has agreements with the Washington Department of Fisheries, the Washington Department of Game, the Oregon Department of Fish and Wildlife, and the State of California Department of Fish and Game; for the protection and maintenance of viable habitat for fish and wildlife.

Pest management activities have the potential to affect fish habitat. Elements which might be affected include water temperature and water quantity, sediment loading, turbidity, timing of stream flows, and the character of streamside vegetation. There are particularly important concerns for effects of management practices within the riparian zone (the interface between terrestrial and aquatic ecosystems).

Recreation/Public Use

National Forests of the Pacific Northwest offer widely diverse natural landscapes; which range from seacoast to alpine meadow, from river gorge to desert. They offer a correspondingly wide range of recreation opportunities; from swimming and clam digging, to hiking and skiing. And the Forests are open year-round.

There are two Forest Service classifications for recreation: 'dispersed', and 'developed'.

Dispersed recreation consists of activities that involve little interaction between users. Examples of this include hiking, hunting, and camping in undeveloped or remote locations.

Developed recreation is a concentrated form of recreation which offers a full range of facilities; from 'primitive' campgrounds to all-season resorts. Other kinds of sites include family and group campgrounds and picnic areas, winter sports sites, and swimming and boating sites.

The Regional Forester's objective is to increase the supply of outdoor recreation opportunities and services through programs that emphasize dispersed recreation. Current use levels of developed or concentrated site recreation will be maintained.

Use of the Pacific Northwest Region's developed recreation sites (there are slightly over 1,900) accounts for over 13 million Recreation Visitor Days (RVD's) annually. A Recreation Visitor Day is equal to 12 hours spent by a visitor. This figure includes RVD's at Forest Service operations, permittee operations, and privately owned sites within National Forest boundaries.

Dispersed recreation accounts for over 18 million Recreation Visitor Days per year on approximately 1,700 dispersed recreation areas.

Forest pests may influence the recreational use that an area receives. In areas where significant pest-caused mortality is visible, outdoor recreation enjoyment may be reduced.

Visual Resources

Scenic diversity in the Pacific Northwest Region contributes greatly to the recreational value of our National Forests. The coastal forests, the jagged peaks of the North Cascades, the high desert of central Oregon, moss-draped trees in the Olympic rain forest, the Blue Mountains, and the Snake River canyon; all provide the public with unique visual enjoyment.

The American public expects to see a natural landscape when they visit the National Forests. This type of landscape exists on most of the Forests in the Pacific Northwest Region. One of the Forests' objectives is to manage all National Forest System lands in a way which will sustain the highest possible visual quality which is compatible with other appropriate public uses, costs, and benefits.

Sightseeing is an important component of Forest recreational activities. Most 'viewsheds' are accessed by roads, trails, river corridors and other public travelways.

Management practices which result in alterations to the landscape include harvest activities, creation of utility corridors, prescribed fire and fire suppression, and construction of recreational facilities. Maintaining high visual quality tends to reduce timber harvest levels, and increase timber management and road construction costs. Since maintaining a natural appearance often requires retention of large trees and snags, benefits to some species of wildlife are significantly increased as an indirect result.

Spruce budworm infestations may cause "browning" or defoliation of the forests, a result which may cause public concern. Recent examples of insect damage effects on visual quality are evident in the Deschutes National Forest's lodgepole pine stands which are infested with mountain pine beetle, and in the damage resulting from a tussock moth epidemic which spread through the Wallowa-Whitman in the 1970's.

Salvage efforts often follow these natural events. Removing dead and down timber to supply lumber and chip markets also reduces the potential for catastrophic wildfire. But salvage activities may also reduce visual quality in some instances.

Cultural Resources

Cultural resources are remnants of past human habitation or endeavor. Artifacts, buildings, or historical sites are identified and recorded when they are found, and are protected under law. They can be archaeological (generally associated with Native Americans), or historical (associated with early settlement and development). Examples of cultural resources are footpath and wagon road remnants, and abandoned trading posts and homesteads.

Cultural resources are irreplaceable, finite resources. They may have historical, archaelogical, architectural, scientific, or cultural value which is of great interest and concern to the public. In order to protect these National treasures, Congress legislated the Preservation of American Antiquities Act of 1906; the National Historic Preservation Act of 1966, amended in 1980; the Archaeological Resource Protection Act of 1979, Executive Order 11539; and the American Indian Religious Freedom Act.

These laws and regulations require Federal agencies to manage the significant cultural resources within their jurisdiction. To accomplish this, a combination of inventorying methods, and protection and enhancement actions are taken. Cultural resource laws and regulations provide that specific procedures must be followed, to ensure that cultural resource values are considered in any decisionmaking process.

Social Conditions

In the Pacific Northwest Region, the people and communities of Oregon and Washington are the ones most directly affected by National Forest management activities and resource or commodity output. A description of the social and economic conditions of these two States, and their principal ties to National Forests in the Region follows:

Oregon and Washington contain a great variety of landforms, which describe the effects of hydrologic, volcanic, and glacial events. A major geological feature in the Region is the Cascade Mountain Range, which parallels the Pacific coastline about 100 miles inland. These rugged mountains divide the Region into two distinct zones, west and east. Climate and vegetation, as well as population patterns and economic structures differ between areas east and areas west of the Cascades.

There are about 5.7 million people west of the Cascade crest, a majority of the population of the two States. Eighty-seven percent of Oregon's population and 69 percent of Washington's reside west of the Cascades. Population centers are concentrated along the Puget Sound in Washington and in Oregon's Willamette Valley.

They are linked by north-south Interstate Highway 5, and by the Southern Pacific, Burlington Northern, and

Union Pacific railroads. Major ports on Puget Sound, the Columbia River and Coos Bay provide trade links to the Pacific Ocean nations.

The economy in the western portion of the region is relatively diversified; more so in Washington than in Oregon. Aircraft manufacturing, shipbuilding, forest products industries, major financial centers, service and trade centers, educational centers, government, commercial fishing, agriculture, the livestock industry, recreation facilities, and mining all contribute to the economic picture.

The eastern part of the region covers two-thirds of the land area of Oregon and Washington. It contains a smaller proportion of the population: about 13 percent of Oregonians and 31 percent of Washingtonians live east of the Cascade Mountains. Oregon has no metropolitan areas on the East-side; Washington has Yakima, The Tri-Cities (Richland, Kennewick, Pasco), and Spokane.

Major transportation linkages include Interstate Highway 90 and the Burlington Northern Railroad (providing east-west transportation), supplemented by the Columbia River corridor with rail, Interstate Highway 84, and barge transportation. The remaining East-side area is not as well-served.

The economy of the eastern portion of the region depends more on agriculture, forest products industries, and the livestock industry than does the western portion. The relative dependence on these sectors has not been balanced by growth in other major employment sectors, except for some localized growth in the recreation and service industries. The East-side has fewer opportunities for employment. The cities and towns reflect a rural-based economy with little diversification.

The Pacific Northwest is a region in transition. It is moving toward a more diversified economic base. The traditional employment sectors simply do not have the same labor requirements as they did in the past. Historically, many seemed to feel that the natural wonders of the area would be sufficient to guarantee its growth. Actually though, growth has declined markedly, as shown in Table III-IV.

Population

The population of Oregon and Washington was 6,673,312 in 1980, an increase from the previous two decades of over 2 million people, or about a 1.9 percent annual growth rate. Since 1980, the annual rate of growth has slowed to 0.8 percent, the majority of which has occurred in Washington.

Urban/Rural Population

There are significant differences between Washington and Oregon in the distribution of population. Washington contains 61 percent of the region's population. The vast majority of these residents live in urban areas. There are five metropolitan areas in western Washington: Bellingham, Seattle-Everett, Bremerton, Tacoma, and Olympia. Three more are east of the Cascades: Yakima, Spokane, and Richland-Kennewick-Pasco.

Oregon's population, 39 percent of the region's total, is also primarily urban. The State has four metropolitan areas, all on the west side of the Cascades: Portland (which might also be said to include Vancouver, Washington), Salem, Eugene-Springfield, and Medford. Table III-V shows the 1980 distribution of population between urban and rural areas.

Minorities

Racial and cultural minorities are a small segment of the two States' population. In 1980, Blacks comprised 2 percent of the population, Native Americans 1 percent, Hispanics 2 percent, and Asians 2 percent. Blacks in the region are predominately urban dwellers, while Native Americans and Hispanics are more rural than the overall population.

There are over 20 Indian Reservations in the two States. Many are adjacent to National Forests, and Native Americans have significant concerns about Forest resources and management.

Age, Sex, and Labor Force Participation

After 1970, the age composition of the region's population shifted, and by 1980 a larger proportion of the population was of working age than ever before. A significant increase, from 43 percent to 52 percent, in the number of women in the labor force occurred. As the age structure of the region continues to shift, the size and other characteristics of the labor force will be impacted (Bonneville Power Administration, 1982).

Economic Conditions

The Pacific Northwest has a history of dependence on resource-based industries. Diversification, an ongoing process, is more advanced in Washington than in Oregon. The Pacific Northwest Region is noted for its environmental quality, is located favorably for foreign trade, and has a well-educated work force.

TABLE III-IV

Population Size and Growth Rates
Oregon and Washington

				Average Annual Rate of Increase (Percent)	
	1960	1980	1986	1960-1980	1980-1986
Washington	2,853,214	4,130,163	4,419,700	1.9	1.1
Oregon	1,768,687	2,633,149	2,659,500	2.0	0.2
TOTAL	4,621,901	6,763,312	7,079,200	1.9	0.8

Source of 1960 and 1980 Data: 1980 Census. 1986 Oregon data calculated from Table 3 of Population Estimates of Oregon, Counties and Cities, July 1, 1986, published by the Center for Population Research and Census, School of Urban and Public Affairs, Portland State University. 1986 Washington data calculated from Table 9 of 1986 Population Trends for Washington State, August, 1986, published by the Office of Financial Management of the State of Washington.

TABLE III-V

Population Distribution
Urban and Rural, 1980

	Urban	Rural
Washington	74%	26%
Oregon	68%	32%

The major centers of growth and diversification are in the Puget Sound, Spokane, and Willamette Valley metropolitan areas. Though employment in agriculture, and lumber and wood products has declined over time, the natural resources of the region will continue to play an important role in its economic security. Table III-VI summarizes recent area employment.

Employment data from the two States are not necessarily comparable due to differences in definitions. Data shown represent figures gathered from documented employment records, and so do not reflect proprietors, family member working on farms, etc.

Lifestyles, Attitudes, Beliefs, and Values

Many people find the Pacific Northwest a desirable place to live. To some extent this quality has fostered the location of new enterprises in the area. The 1980's though, are likely to be remembered as a time when people in the Pacific Northwest recognized that the region's continued growth could not be ensured without effort — that it would have to attract suitable employers from a common, National pool; that other areas of our Country are indeed viable competition in our mutual marketplace.

Certainly, there is no one regional lifestyle or set of attitudes, beliefs, and values. Generalizations which typify an area's residents are as inaccurate today as they were in the past. Continuing advancements in technologies are helping shift metropolitan economies from their historical resource bases to more diversified ones. Strong environmental concerns are being voiced

TABLE III-VI

Employment in Oregon and Washington in the Mid-1980's
(Thousands of Jobs)

	Oregon	Washington	Total
Total (100%)	1,210	1,617	2,827
Lumber & Wood Products	64 (5.3%)	41 (2.5%)	105 (3.7%)
Paper & Allied Products	9 (0.7%)	16 (0.9%)	25 (0.8%)
Agriculture, Forestry, and Fishing	23 (1.9%)	44 (2.7%)	67 (2.4%)

Oregon data for the above table are for 1985. They were taken from page 2 of "Oregon Industrial Outlook," published by the Employment Division, Department of Human Resources, State of Oregon (RS PUB 78 (5-86)). Washington data for the above table are for 1984. They are taken from page 113 of "Employment and Payrolls in Washington State by County and Industry," Fourth Quarter 1984, No. 153, January 1986.

in sectors of our society where previously little was ever said.

Because the economies of the rural communities are often associated with commodity production, residents of those areas are frequently perceived as being more likely to favor higher production levels and heightened development. Residents of metropolitan areas whose livelihoods are not directly or noticeably linked to the extraction of natural resources are more commonly viewed as favoring environmental concerns.

Environmentalists live in rural areas as well as in metropolitan areas, just as do those who favor development of the resource base. There is no simple line of demarcation between these camps. Environmentalists are concerned about their neighbors' jobs, and millworkers are frequently among the first to note their concern for the environment.

The economy of the Pacific Northwest is slowly, but surely, moving toward greater diversity. The region's historic dependence on the removal of natural resources and the manufacture of 'raw' products, has lessened with the increase in other kinds of growth. With the social changes effected by these new directions has come a fresh recognition of the importance of our National Forests. The opportunity to enjoy an unpolluted environment, to pursue one's favorite outdoor recreation, or to view a truly natural diversity, is still possible in the National Forests.

Forest pests can have dramatic impacts on the social and economic components of the environment. Major infestations of western spruce budworm, Douglas-fir tussock moth, mountain pine beetle and the gypsy moth may have adverse economic impacts on both local and regional communities. The impacts can be expressed in terms of lost jobs due to an impending scarcity of resources.

Land Uses

Land ownership patterns within the Pacific Northwest Region are complex, both around and within National Forest boundaries. Many of the private holdings are managed for timber production by private, industrial owners. State and Federal agencies (the Oregon Department of Forestry, Washington Department of Natural Resources, and the USDI Bureau of Land Management, for example) also manage large tracts of land within and adjacent to boundaries of Forests in the Region.

The Region is comprised of 24,545,814 acres of National Forest system land (1986 figures). This land is contained within 23,894 linear miles of boundary.

Also contained within this boundary are 2,765,197 acres of lands of other ownerships.

The owners of small parcels of land use their holdings in a variety of ways: recreational residences, farms, small woodlots, and small businesses; to name a few. Generally, industrial landowners tend to emphasize uses of the environment which differ from those emphasized by other owners. Large, private timberland owners will usually manage their property for timber production. Less emphasis may be given to other resources values on these lands. A "checkerboard" effect will often result where these ownerships adjoin one another or National Forest land. This can prove to be a complicating factor in the management of forest pests.

Human Health

In 1984 the combined population of Oregon and Washington was approximately 7 million people. Washington's population was 4.35 million people; Oregon's was 2.67 million. Census figures and other data suggest that people in the Pacific Northwest enjoy above average good health.

The overall 1982 death rate per 100,000 in Washington was 755.4; in Oregon, 810.1; and in the U.S., 852.0. The figures for cancer deaths were 171.0, 179.4, and 187.2, respectively. In contrast, the death rates from accidents were 41.4 in Washington, 41.6 in Oregon, and 40.6 nationally.

The Forest Service estimates that 100,000 people live within 1 mile of National Forests (including 30,000 who live within a quarter-mile). The Forest Service reports a trend of increasing numbers of residents living near National Forests.

This increasing number of people living near Forest Service lands has resulted in increasing public concern with environmental issues such as air and water quality and public health. In particular, concerns have been raised about the use of pesticides.

Background Health Risks in the Pacific Northwest

This section discusses background human health risks of injuries, cancer, and other diseases which affect people who live in in the Pacific Northwest. As is true for the U.S. population as a whole, people in the Pacific Northwest are exposed to all manner of risks: automobile accidents; contaminants in the air, water, and soil; chemicals in the diet; and many other injuries and diseases. Some of these risks can be quantified, while lack of data allows only a qualitative description of others. In some subject areas, information is available only for the Nation as a whole. In such cases, it is assumed that the U.S. data apply in equal measure to residents of the Pacific Northwest.

This section includes detailed discussions of the ten leading work-related diseases and injuries listed by the Centers for Disease Control (U.S. Department of Health and Human Services, 1987) Summaries of vital statistics (births and deaths) for Washington and Oregon (Washington State Department of Social and Health Services, 1986 and Oregon Department of Human Resources, 1987); the National Research Council's "Regulating Pesticides in Food—the Delaney Paradox" (NRC, 1987) and "Injury in America", and "Healthy Living in an Unhealthy World" (Calabrese and Dorsey, 1984) are also cited. Except for certain infectious, notifiable diseases, there is little statistical information on nonfatal conditions, including cancer, that either are cured or are not the primary cause of mortality.

Risks from Injuries

Injury Incidence

Seventy million Americans incur nonfatal injuries every year. Among persons less than 45 years old, injuries are the leading cause of hospitalization (NRC, 1985).

NIOSH estimates that about 10 million traumatic injuries occur annually to people at work in the United States (U.S. Deaprtment of Health and Human Services, 1987). Several chronic injuries also are directly linked to the type of work done. For example, vibration syndrome affects up to 90 percent of workers using chippers, grinders, chainsaws, jackhammers, or other handheld power tools, causing blanching and reduced sensitivity in the fingers (U.S. Deaprtment of Health and Human Services, 1987). Noise-induced hearing loss affects 17 percent of U.S. production workers who are exposed to noise levels of 80 decibels or more on a daily basis (U.S. Deaprtment of Health and Human Services, 1987).

Injury Mortality

Approximately 140,000 Americans die from injuries every year. Of the 94,072 deaths from unintentional injury in 1982, 47.5 percent were due to motor vehicle accidents, 12.8 percent to falls and jumps, 6.8 percent to drowning, 3.7 percent to poisoning, and the other 29.2 percent to a wide range of causes (NRC, 1985). Injuries are the major cause of death among young adults and children. From the ages of 15 to 24, injuries cause almost 80 percent of the fatalities (NRC, 1985).

Injuries cause about 10,000 occupational fatalities per year (U.S. Deaprtment of Health and Human Services, 1987). Some of the causes include highway motor vehicle accidents (34.1 percent in 1980 to 81), falls (12.5 percent), industrial-vehicle or equipment accidents (11.4 percent), and fires (3.4 percent) (U.S. Deaprtment of Health and Human Services, 1987). Workers in the mining and quarrying industry had the highest rate of traumatic deaths, at 55 per 100,000 workers. Agriculture had a rate of 52 deaths per 100,000 workers, while trade had only 5 deaths per 100,000 workers (U.S. Deaprtment of Health and Human Services, 1987).

In Washington, 1985 data show that out of 34,475 total deaths, 830, or less than 3 percent, were accidental, nonvehicular fatalities. Of these, 252 were from falls, 104 from poisoning, 98 from drowning, 69 from fire, at least 64 from mechanical trauma, and the rest from various other types of accidents. Over one-half occurred in the place of residence (Washington State Department of Social & Health Services, 1986).

Table III-VII indicates that deaths from falls, fires, and accidental poisoning are relatively rare in both States. Forestry-related deaths from any of these causes are exceptionally rare in either State.

Risk of Cancer

Cancer Incidence

Nationwide, the chance of developing some form of cancer during one's lifetime is about 1 in 4 (Calabrese and Dorsey, 1984 and NRC, 1982). The causes of cancer development are many, including occupational exposure to carcinogens, environmental contaminants, and substances in food. In the United States, one-third of all cancers have been attributed to tobacco smoking (Chu and Kamely, 1988). It is estimated that work-related cancers account for anywhere from 4 to 20 percent of all malignancies (Centers for Disease Control, 1987); however, it is difficult to quantify the information because of such factors as long intervals of time between exposure and diagnosis, personal behavior patterns, job changes, exposure to other carcinogens, and difficulties in documentation.

Diet plays a significant role in cancer incidence. Different estimates hold diet responsible for anywhere from 30 to 90 percent of all cancer in humans (National Research Council, 1982). Pesticide residue

TABLE III-VII

Mortality Rates and Causes of Death in the Pacific Northwest

	Number of Deaths *(Mortality Rate)*	
Cause of Death	Oregon 1/	Washington 2/
All causes	23,328 (877.2) 3/	34,475 (786.4)
Heart disease (rate)	7,788 (292.8)	11,713 (267.2)
Cancer (rate)	5,272 (198.2)	8,007 (182.6)
Cerebrovascular disease	1,926 (72.4)	2,709 (61.5)
Accidents	1,184 (44.5)	1,635 (37.3)
Motor vehicle	638 (24.0)	805 (15.4)
Falls	ND	252 (5.7)
Fire	ND	69 (1.6)
Poisoning	ND	104 (2.4)
Respiratory disease	1,090 (41.0)	1,951 (44.5)
All other causes	6,068 (228.2)	8,460 (193.0)

Sources: Oregon Department of Human Resources, 1987;
Washington State Department of Social & Health Services, 1986.

1/ 1986.

2/ 1985.

3/ All numbers in parentheses are rates per 100,000.

ND: No data.

in foods contribute to the total cancer risk encountered. Based on a study conducted by the NRC in their review of oncogenic pesticides, overall risks of cancer are increased over the background cancer risk rate of 0.25 (1 in 4 lifetime risk), by 0.001 in the United States as a whole. Most of this increased risk is attributable to a single group of compounds, the fungicides. These herbicides contribute 27.1 percent (of the 0.001 increased risk), which is equal to 0.000271 increased risk. Virtually all herbicide risk is due to a single compound, linuron, which makes up 96.1 percent of the herbicide risk and 26 percent of the total risk from pesticide residue in food (NRC, 1987).

Cancer Mortality

Based on the data in Table III-VII, cancer accounted for 22.6 percent of all 1986 Oregon fatalities, and 23.2 percent of 1985 Washington fatalities. These figures reflect national cancer mortality figures, where cancer is shown to account for 22.1 percent of 1985 deaths in the United States (U.S. Bureau of the Census, 1987).

Risk of Diseases other than Cancer

Disease Incidence

According to the Centers for Disease Control (U.S. Department of Health and Human Services, 1987), clear causal links have been established between certain occupations and specific illnesses. Asbestosis, for example,has been linked to shipyard and insulation workers' exposure to asbestos; while pneumoconiosis among coal miners has been linked to their inhalation of coal dust. Occupational exposures to some metals, dusts, and trace elements, as well as carbon monoxide, carbon disulfide, halogenated hydrocarbons, nitroglycerin, and nitrates, can result in an increased incidence of cardiovascular disease. Occupational exposure to lead and ionizing radiation may lead to reduced male fertility. Female laboratory and chemical workers show a higher rate of miscarriage than the general population. Neurotoxic disorders can arise from exposure to a wide range of chemicals, including such commonly used pesticides as 2,4-D, methyl bromide, and organochlorine insecticides. Dermatologic conditions, such as contact dermatitis, infection, trauma, cancer, vitiligo, urticaria, and chloracne, have a high rate of occurrence in the agricultural, forestry, and fishing industries, with 2,233 reported cases in 1984 and an incidence rate of 28.5 per 10,000 workers.

Disease Mortality

The mortality rates for Oregon (1986) and Washington (1985) are listed in Table III-VII. The leading causes of death are listed, along with numbers of deaths and rates per 100,000. The Oregon death rate slightly exceeds the national average of 870 per 100,000. The Washington rate is well below the national average. Heart disease is the principal cause of death in both States. Other significant disease-related deaths include cerebrovascular disease and respiratory disorders.

Chapter 4: Environmental Consequences

Moth (adult)

CHAPTER IV. ENVIRONMENTAL CONSEQUENCES

Introduction

This chapter discloses the environmental consequences of implementing any of the Alternatives described in Chapter II.

In June and July of 1988, the Interdisciplinary Team used an open, public process to identify the significant Issues which are addressed in this EIS. These Issues were used to formulate a range of Alternatives, and to provide a basis for consideration of the effects of implementing those Alternatives.

Three of the nine identified Issues expressed specific concerns for potentially significant adverse impacts on the human environment. These potential impacts are in the areas of human health, social and economic effects, and environmental effects. See Chapter I for a discussion of the Issues and the scoping process.

Background

Estimating Environmental Consequences

Environmental consequences result when changes are made to ecosystems; changes which may be brought about either by commission or omission. Under each of the action Alternatives, western spruce budworm populations would be managed using either a biological or a chemical insecticide, or a combination of both. This chapter explores the environmental consequences of implementing a No Action Alternative, or any of four action Alternatives.

The various environmental components, such as soils, wildlife, and the social and economic spheres which might be affected, form the core around which this chapter is organized. Direct environmental effects are then discussed, along with the reasons they occur. Changes in one aspect of the environment often lead to changes in other aspects. These indirect effects are also presented.

Standards and Guidelines for mitigating impacts caused by implementation of the action Alternatives are described in Appendix C. In estimating environmental effects, these mitigating measures are assumed to be in place and effective.

Site-specific Environmental Effects

A program for managing western spruce budworm infestations will involve many site-specific projects in the Region over a period of several years. Environmental consequences will be different for each project, because the combination of environmental factors is unique to every project site.

If an action Alternative is selected, this EIS prescribes that a project-specific environmental analysis will be conducted for each proposed budworm management project. The appropriate disclosure document will be prepared for each year's proposed treatment(s) and made available for public review. This analysis tool would consider individual projects, and would involve the public in the decision making process. If the No Action Alternative is selected, monitoring of the current budworm epidemic will continue.

Regional Environmental Effects

Areas of the Pacific Northwest Region which support western spruce budworm populations are extensive. Current infestations are located primarily in East-side Forests, but have spread across the Cascades and into West-side Forests. The ID Team was faced with the problem of discerning the environmental effects of treatment in both of these areas.

Resource managers and specialists on individual National Forests are familiar with the extent of infestation and actual damage to resources under their care. Whenever possible, the team consulted with these people. These consultations, available research material, and the ID Team members' specialized knowledge of ecological processes, have provided a basis for estimating the environmental impacts.

Much of the material on human health effects was compiled, analyzed, and reviewed by Labat Anderson Incorporated, a private contractor in Arlington,

Virginia, who specializes in conducting quantitative risk assessments.

Water Quality/Quantity

It has been known since the early 1900's that removal of forest vegetation increases streamflow. This is primarily a result of reduced transpiration and interception. In addition, an increase in soil water storage can be anticipated due to a decrease in transpiration. These effects are most pronounced immediately after removal of vegetation. Effects decrease as the vegetation recovers or the area is reforested and trees mature. The magnitude of the increase or decrease is a function of climate, topography, percentage of vegetation removed, soil, water storage and other environmental factors (Hibbert, 1967). There may or may not be an increase in runoff, dependent upon these factors.

On the Nez Pierce National Forest it was shown that water yield from areas in the snow zone increased by as much as one third after timber harvest (Silvey, 1973). Since these increases resulted from a disruption of the shear plane at canopy level, caused by the removal of trees; it follows that no significant impact should be produced by a budworm infestation. Increases in snow accumulation due to reduced interception would still be expected.

Most research related to hydrologic effects of insect infestation has dealt with bark beetles. A severe outbreak of Engelmann spruce beetle occurred in the White River National Forest between 1939 and 1946. Up to 80 percent of the Engelmann spruce and lodgepole pine were killed, over 30 percent of the gauged watersheds in the White River drainage. Helvey (1978) indicated that most of the Engelmann spruce and lodgepole pine in a 226 square mile area were killed. Even after 25 years, the runoff was 10 percent above projected pre-infestation levels (Bethlahmy, 1975).

In southwest Montana a pine beetle epidemic killed thirty-five percent of the timber in the 51.5 mile Jack Creek watershed, a sub-drainage of the Madison River (Potts, 1984). Gauging records showed there had been a 15-percent post-epidemic increase in flow with a 2- to 3-week advance in the hydrograph (spring runoff and peak flow). There was a 10-percent increase in base flow. No significant increase was observed in peak flow.

Helvey (1978) studied the effects of Douglas-fir tussock moth defoliation on streamflow in three drainages in the Blue Mountains of northeast Oregon and southeast Washington. Because the tussock moth and budworm are both defoliators, these results most closely approximate the impacts associated with a spruce budworm infestation. Helvey assumed top-kill removed one-half the transpiring surfaces, and heavy mortality removed all surfaces. No change in streamflow was detected in the lightly defoliated basins (13 percent and 16 percent), and no effect on peak flow was detected on any of the drainages. The Umatilla Basin, which was 25 percent defoliated, showed a statistically significant increase, but in the third year only. Helvey postulated that if this increase during the third year was due to defoliation, the return to nonsignificant flows the following year was probably due to greenup (vegetative recovery).

A study of tussock moth defoliation on the Umatilla National Forest by Hicks (1977), found no significant difference in water quality between affected and unaffected watersheds.

In a world-wide literature review, Hibbert (1967) determined that at least 20 percent of a basin must be deforested before a significant increase in runoff can be detected. This is consistent with the results published by Potts (1984) and Helvey (1978). Hibbert attributed this to increased water use by remaining trees and vegetation, with experimental error associated with base-line data. Increases in streamflow are normally derived from U.S. Geological Survey (USGS) gauging records. Records are rated as "good" by USGS when 95 percent of the daily discharge values are within 10 percent of the true value. Therefore, an increase of less than 10 percent cannot be detected.

In 1973 Silvey developed the concept of equivalent clearcut area (ECA), to define the total area within a drainage which has been cleared. The total ECA is the sum of all clear-cut harvest areas and the ECA which is allowed for partial-cuts, selective-cuts and roads. In a stand composed almost exclusively of non-resistant species, which also has no significant vegetative ground cover, this buffering effect would not be significant. Therefore, the level at which defoliation produces a significant increase in flow should be somewhat higher than 20 percent.

While vegetation removal in the Pacific Northwest may increase annual flow, it does not appear to significantly increase peak flow discharge rates (Harr, 1976). In the northern Rocky Mountains though, where annual runoff is primarily dependent upon snowmelt, studies indicate that timber harvest can increase peak flow (Bethlahmy, 1973; Galbraith, 1973). Based on procedures outlined in Forest Hydrology, Part II (USDA Forest Service, Region 6), it is possible to harvest timber without increasing peak flow; by distributing units to maximize snowmelt

timing. The absence of any significant increase in peak flows after insect infestation tends to confirm that distribution of timber harvest throughout a basin should not increase peak flow.

The channel maintenance flow concept used in Forest Service Handbook (FSH) 2509.17 to quantify flows needed for self-maintenance of stream channels, assumes stream channels result from a range of frequently occurring flows. Sediment yield is a function of the frequency and duration of flows which are above the mean annual discharge (Rosgen, 1986). Therefore, fluctuations in streamflow, as well as peak flow, will effect sediment loading and bank erosion.

The earliest stages of spruce budworm infestation will only affect new foliage. Four or five continuous years of infestation are necessary to produce severe defoliation. The tussock moth, on the other hand, attacks all foliage. Infestations will produce severe defoliation by the second year. Because defoliation occurs more gradually in budworm infested stands, unaffected vegetation will increase in density and use a large share of the available water. For this reason, and because lower mortality levels result from budworm infestations, a smaller increase in flow is produced by budworm than by tussock moth.

The maximum anticipated basin defoliation rates projected for a spruce budworm infestation is similar to those anticipated for the tussock moth. Because of this, no statistically significant increase in streamflows or peak discharges should result solely from the impact of spruce budworm. However, statistically significant increases in annual streamflow could result from the cumulative impacts of severe budworm defoliation and harvest activities. In streams incised in alluvium which can be moved by flows at or below bank full, increases in annual flow resulting from cumulative effects could result in increased sediment loading and bank erosion. Areas for which there is concern include streams that are actively aggregating or degrading, and streams with high livestock impacts.

Alternative A - No Action

Alternative A, the No Action Alternative, would result in few significant impacts to water quality and quantity. Maximum total defoliation would be no greater than 25 percent. Less than 3 percent of affected trees would die. No significant increase in annual streamflow or peak discharge is anticipated. Defoliation and mortality could slightly increase water temperature in some lengths of stream, but this would have a small spatial impact and would not be significant. In watersheds where there are extensive, ongoing management activities, the cumulative impacts of these activities and budworm defoliation could produce a significant increase in annual streamflow. While no additional increase in peak flow should occur, the increase in annual flow could degrade water quality. These impacts could delay the implementation of additional activities until either the budworm epidemic subsides or vegetation on harvested units recovers enough to lower the increased runoff or sediment loading.

Alternatives B, C, D and E

Implementation of Alternatives B, C, D and E would reduce defoliation and eliminate the slight impacts described under the No Action Alternative. Reduced defoliation would also lessen the cumulative impacts described under Alternative A.

Mitigating Measures

Aerial insecticide application near streams and open water is controlled by State law. In Oregon, State regulatory agencies have agreed that *B.t.* may be aerially applied adjacent to but not over streams and open water. A variance must be obtained from the Washington State Department of Ecology to apply *B.t* adjacent to streams in that State.

A buffer zone would be left adjacent to streams, lakes, wetlands, and other waterways when carbaryl is applied. This buffer strip would be at least one swath wide.

The following measures would be used to reduce the probability of accidental spills and application errors.

Aircraft spray equipment calibration testing over wetlands or floodplains would be prohibited.

A pilot car would be required if insecticides or fuel are transported over roads within municipal watersheds.

Helispots would not be located in or adjacent to meadowlands or floodplains.

Insecticides would not be sprayed over wetlands, including lakes and ponds, which are large enough to be identified from the air.

Soils

Alternative A - No Action

Alternative A would have no effect on soil properties. Loss of vegetation would not be great enough to cause erosion. Some localized soil compaction might occur when dead trees are salvaged. There would be no cumulative effects on the soil resource due to implementation of this Alternative.

Alternatives B, C, D and E

Implementation of an action Alternative would have minor effects on soil chemistry and microbiology. Under these Alternatives, carbaryl and/or *B.t.* would be applied aerially. There would be no mechanical effect upon soil structure. The major consideration would be persistence of these insecticides in the soil.

This persistence depends on the insecticides' chemical properties, climatic factors, soil properties, and initial rates of application. Many soil microorganisms are capable of breaking down the insecticides which are proposed for use.

Carbaryl has a soil half-life of 14 days (Environmental Protection Agency 1986b). Degradation of carbaryl in the soil results primarily from the metabolic activity of microorganisms (Heywood, 1975). A half-life of 8 days has been reported by Johnson and Stansbury (1965). Only 6 percent of applied carbaryl could be recovered from treated soil 28 days after application. In addition, less than 3 percent remained as water-soluble metabolites. Degradation of carbaryl by soil microorganisms produces several toxic reaction intermediates, including 1-napthol and hydroxymethylcarbamates. It has also been shown that 68 percent of hydroxylated metabolites would be broken down in soil after 9 weeks (Heywood, 1975). Soils placed in storage were found to degrade a variety of carbamate insecticides at a lower rate. Carbaryl has been found to be degraded by the soil fungus *Aspergillus terreus* (Liu and Bollag, 1971). Carbaryl degraded with a half-life of 6 days in A. terreus cultures, and 1-napthol was also metabolized into unidentified degradation products. Soil mite populations are unaffected by carbaryl (Moulding, 1972). Catalysis of carbaryl degradation by soil minerals is not well understood, but it is clear that the degradation of carbaryl in soils can be attributed more to biological activity than to soil mineral composition (Heywood, 1975).

Persistence of *B.t.* in soils was reviewed by Forsberg et al., (1976). *B.t.* formulations appear to be moderately persistent.

Ignoffo and Graham (1967) reported a 90 percent reduction in spore count after 4 months when Bakthan L-69 was applied to soil that was exposed to the atmosphere and to rainfall. Saleh et al., (1970) treated various soils with Thuricide T and with Biotrol BTB wettable powder. They reported recovery of 7,800 to 170,000 spores per gram of soil from silty clay and from two silt loams up to 40 days after application. In laboratory soil studies, these authors reported that *B.t.* spores germinated and exhibited population growth in organically amended soils; but in low pH (5.2) soil that has not been organically amended, the spores germinated while the vegetative cells died.

None of the action Alternatives would produce any short- or long-term cumulative effects, since such small amounts of chemicals would reach the soil.

Climate

Climate interacts with all other environmental components, both directly and indirectly. However, western spruce budworm management activities are not expected to have significant or cumulative effects on the regional climate. Climate plays a major role in the suitability of host species for major western spruce budworm epidemics.

Stress created in the host species by drought conditions has intensified the present epidemic. Stressed trees are more susceptible to attack by insects or disease. Less than normal amounts of precipitation has been one of several factors contributing to the present situation.

Vegetation

Plant Communities

Alternative A - No Action

Over time, the No Action Alternative would allow mortality which would open pockets in the canopy. These pockets would receive more sunshine and could allow less shade-tolerant and more insect-resistant trees, such as various pine species, to become established. The stand structure would slowly change to include a mixture of species which are less susceptible to attack by spruce budworm. The cumulative effect of this Alternative would be a gradual change of stand composition.

Alternatives B, C, D and E.

The action Alternatives would tend to keep timber stands and attendant plant communities in their present successionary state. The stands would continue to be composed of susceptible species such as true firs and Douglas-fir. As the stands are brought into a managed condition through implementation of Forest Plans, stand compositions will change to a mixture of species which are less susceptible to western spruce budworm infestation. No cumulative effects on other vegetation would result from implementation of any of the action Alternatives.

Timber

Timber stands affected by the current spruce budworm outbreak have sustained various types and degrees of loss in wood fiber production. Diminished wood fiber production is primarily a result of radial growth loss. Additional reductions are due to top-kill, tree deformity, and tree mortality. Reduced seed production may also be attributed to spruce budworm damage. All of these effects are sometimes present within relatively small areas. As a rule, the affected areas are unevenly distributed throughout a general zone of infestation. The spread of infestations has caused considerable concern among local land managers. For an explanation of the method used to quantify volume losses in the site specific environmental analysis, refer to Appendix G.

Potential for Radial Growth Loss

Alternative A - No Action

Radial growth loss is a major impact of budworm defoliation. By feeding on tree foliage, budworm larvae reduce the host trees' vigor. Reduced height and diameter growth result from this loss of vigor. The growth of a stand of trees is dependent on species composition, tree size, tree age, stocking levels, and site quality. Where a large proportion of host tree species are present in a stand, trees will sustain greater growth loss than in stands composed of a mixture of species. Grand fir is known to exhibit more damage from budworm than Douglas-fir (Carolin, 1975). Numerous studies have shown that radial growth loss exceeds the loss resulting from foliage removal by 1 to 3 years (Alfaro et al., 1982; Crimp, 1982). Similarly, growth recovery lags behind cessation of defoliation.

Radial growth loss is most often described relative to pre-outbreak growth rates. An annual increment reduction of 40 to 80 percent in affected Douglas-fir has been observed (Shepherd et al., 1977). Gregg et al., (1979) found the mean annual increment, relative to predicted growth, to have been reduced by 12 percent in Douglas-fir and 27 percent in true fir, after five continuous years of defoliation.

Height growth is also affected by budworm defoliation. Severely defoliated Douglas-fir in British Columbia produced no height growth for a period of 10 years (Shepherd et al., 1977). In affected areas in Washington, where defoliation occurred for a shorter time period, height growth loss was compensated by lateral shoots quickly achieving dominance. The proportional loss of height growth was equal to or less than the loss in diameter growth (Scott and Nichols, 1983).

The combined loss of radial and height increment results in stand volume loss over time. Stand volume losses are usually calculated as the difference between observed volume and predicted volume. Harvey reports average stand volume in north-central Washington after a 10-year outbreak to reflected a 2.9 percent loss of predicted growth. In Idaho, stand volume losses were calculated as 1 percent less than predicted growth (Bousfield et al., 1975).

In young stands exhibiting top-kill or mortality, precommercial thinning may be postponed until the epidemic subsides, to ensure that severely damaged trees are removed and the best trees are retained for future growth. Delays in pre-commercial thinning defers the benefits of release and probably will lengthen the stands' rotation age.

An increase in radial growth of non host species such as pine can compensate the losses incurred in a defoliated stand. In western Montana, an accelerated radial growth in pine species among defoliated stands has been verified (Carlson and McCaughey, 1982). This effect has also been demonstrated in Douglas-fir tussock moth infestations (Brubaker, 1978; and Wickman, 1978).

Under the No Action Alternative, the maximum amount of budworm-caused growth loss would continue until natural regulating factors caused a population collapse, or until a subsequent analysis determined that suppression measures were needed. In the long term, as the host trees are replaced by more resistant species, growth loss due to the infestation would become less.

Cumulative effects on the timber resource would be a continuing and expanding loss of fiber production until the outbreak cycle collapsed or stand replacement occurred.

Alternatives B, C, D and E.

Projections show that implementation of these Alternatives would result in a level of budworm population control that would avert most additional loss of wood fiber production caused by the current outbreak. Because of the variance in site productivity throughout the Region, actual projected increases in fiber production would be estimated in site-specific environmental analysis for each Forest.

The magnitude of effects on wood fiber production is determined by the degree to which treatments reduce spruce budworm populations. Both carbaryl and *B.t.* have demonstrated effectiveness in past projects. Most recent projects, however, have used improved

formulations of these insecticides, have followed different application parameters, or have revised the timing of application. Operational evaluations of recent projects in eastern Oregon, where *B.t.* was the sole treatment method, showed very acceptable results in spruce budworm population reduction.

Budworm population levels in the several years following treatment are difficult to ascertain. Budworm may be present in areas adjacent to treated stands. Where populations are increased by re-infestation from adjacent areas, a second insecticide application may be needed. Similarly, if populations rise within a treated unit due to resurgence from endemic or residual populations, a second treatment would also be needed.

One cumulative effect of the budworm epidemic would be a reduction in predicted volume.

Potential for Mortality

Alternative A - No Action

The impact of tree mortality on harvest volumes will vary with the intensity and degree of infestation. Harvest volumes in affected stands can be substantially influenced by present stocking levels, the extent of mortality, the distribution of mortality among diameter classes, accelerated growth in non-host species, physiological stem damage, and general stand vigor; as well as a range of other variable conditions. In some mature stands, trees defoliated by the western spruce budworm may also be attacked by other insects, such as the Douglas-fir beetle or the fir engraver beetle (Fellin and Dewey, 1982). As a result, additional mortality may occur after budworm populations have subsided. Scattered mortality may be beneficial in some instances. Local woodcutters, for example, may enjoy short-term gains from the salvage of dead trees. In some stands, mortality of budworm host trees may actually accelerate the growth of non-host species.

In one extreme case, tree mortality amounted to 39 percent of the total number of trees per hectare. Although mortality was evenly distributed among crown classes, smaller suppressed trees were somewhat more susceptible. (Alfaro et al., 1982). In contrast, Harvey conducted a study in the state of Washington which showed that only 4 percent of the trees in an infested stand had died. It might be concluded that mortality is not always a significant effect of budworm defoliation.

Several moderately damaged stands on the Malheur National Forest were examined in 1986. Douglas-fir mortality ranged from 0 to 18 percent, grand fir mortality from 0 to 5 percent. The heavily damaged stands that were sampled were predominantly Douglas-fir. Mortality in these samples ranged between 6 and 23 percent. With the additional budworm damage that has occurred since 1986, the amount of mortality has also increased.

Under this Alternative, the outbreak would be allowed to continue until natural regulating factors cause its collapse. A maximum amount of defoliation could be expected.

Alternatives B, C, D and E

Under any of the action Alternatives, mortality would not be expected in treated stands which have sustained no previous damage. In stands where tree mortality is already apparent, additional mortality would be averted. Site and stand conditions would often determine the extent to which additional mortality could be expected.

Potential for Top-kill and Deformity

Alternative A - No Action

Top-kill which results from defoliation has three important consequences. 1.) Height growth is reduced during the infestation. 2.) When growth resumes, deformation is likely. 3.) In larger trees stem decay may occur. In general, assessments of top-kill have shown its frequency to vary among and within stands. Evidence of old top-kill was found in 11 percent of the standing Douglas-fir surveyed in British Columbia, but ranged from 0 to 70 percent within individual stands (Collis and Van Sickle, 1978; Shepherd et al., 1977). Alfaro (1986) has shown that top-kill is a major cause of growth loss and a source of stem defects in Douglas-fir defoliated by western spruce budworm. In Idaho, 20 and 70 percent of the grand fir sampled in two stands showed evidence of top-kill from previous budworm outbreaks (Ferrell and Scharpf, 1982). In eastern Oregon, Sandquist and Gregg (1985) devised a system which expressed top-kill in terms of the percentage of total tree height affected by the current year's defoliation. In the grand fir which was sampled the average percent of bare tops ranged from 7.7 percent with an average of 1.8 + 7.2 percent bare top, to 94.2 percent with an average of 13.6 percent + 6.4 percent bare top.

In the spring of 1986 information was collected from Malheur National Forest timber stands which had sustained moderate to heavy damage after four or five years of visible defoliation. In stands exhibiting moderate damage, top-kill in small Douglas-fir (0-23 ft.) was 67%; in medium Douglas-fir (23-46 ft.) 75%; and in large Douglas-fir 55%. In the grand fir which was sampled, the percentages were 55, 85, and 76,

respectively. Trees in this sample which were killed by the infestation comprised 8, 7, and 4 percent of the small, medium, and large Douglas-fir, respectively; and 4, 4, and 4 for grand fir. Heavily damaged stands sampled were composed primarily of Douglas-fir with little or no grand fir. The percentages of small, medium, and large Douglas-fir top-killed were 86, 70, and 83, respectively; the percentages exhibiting bare top were 95, 92, and 90. Trees in this sample which were killed by the infestation comprised 9, 8, and 6 for small, medium, and large trees, respectively; for bare top these percentages were 32, 28, and 16. This suggests that the amount of top-kill has increased since 1986, and will increase more if there is additional defoliation in subsequent years.

Under the No Action Alternative, the maximum amount of top-kill and deformity caused by a full-term budworm outbreak would be experienced.

Alternatives B, C, D and E

Under these Alternatives, the top-kill and tree deformity described in Alternative A would be averted to some degree. Those trees which have not already sustained top-kill could be successfully treated. In those stands where top-kill is extant, further damage would be reduced.

Seed Production Potential

Alternative A - No Action

Western spruce budworm infestations have been shown to cause damage to the cones of Douglas-fir, grand fir, and western larch. In Montana, heavy budworm infestations have resulted in total failure of Douglas-fir seed crops. This caused a lack of natural Douglas-fir regeneration in areas that had sustained significant tree mortality (Dewey 1969, 1972). Another study cited visible damage to about 98 percent of the Douglas-fir cones in a heavily infested area (Reardon et al, 1984).

Under this Alternative, reduced seed production would continue until epidemic populations of spruce budworm collapse naturally. As a direct result, natural regeneration of the host species would be reduced.

Alternatives B, C, D and E

Application of *B.t.* and/or carbaryl to infested areas could avert much of the budworm-caused seed damage. Seed production would therefore be greater than under the No Action Alternative. The chances of establishing stands through natural regeneration would be improved.

A cumulative effect of implementation of Alternative A would be the continued and increasing loss of seed production. Alternatives B, C, D and E would cause no cumulative effect on seed production.

There are no conflicts expected between any of the action Alternatives and other plans and policies for managing the timber resource.

Mitigating Measures

The action Alternatives would mitigate additional loss of fiber and diminished seed production which are caused by the current western spruce budworm epidemic.

Fire And Fuels

Fire Management

The goal of fire management is to use fire to enhance long-term forest and watershed potential, and to lessen those effects of fire which are considered detrimental. To reduce the likelihood of large fires, the Forest Service devotes much effort to fire prevention and suppression.

Fire History

Weather determines the amount of moisture that is contained in fuels. The amount of moisture in fuel particles determines how easily a spark can start a fire and how rapidly a fire will grow.

Fuels range in size from small twigs and dead grass to large logs and duff. As relative humidity lessens, small twigs and grass rapidly become dryer. Small fuels are usually driest during mid-day, when relative humidity is low and temperatures are high.

Surfaces of decaying logs and duff contain small fuel particles (needles, twigs, etc.) which can ignite easily. Yet these logs and duff do not burn readily until they are 'cured' by continuous days or weeks of dry weather. Summers in the Pacific Northwest often provide conditions which will reduce the moisture content of large logs and duff. Extreme conditions can dry even live vegetation to a point where ignition is readily possible. Heavy fuels and dried vegetation will burn for a long time under these conditions.

Fires in the Pacific Northwest tend to be intense, stand-replacing events. The mix of tree species in some timber stands has often resulted from past fires; though post-fire plant succession depends on many other variables as well. Any combination of fire intensities can occur in any stand type, depending on fuels, weather, and topography. Post-fire plant

community diversity may reduce a timber stand's susceptibility to spruce budworm infestations.

The interaction between forests and fire in the Pacific Northwest is complex. Light fires, those which are less intense and remain on the ground, do not necessarily kill trees. In fact, such fires may remove fuel, thereby preventing the occurrence of a catastrophic fire. Intense fires, especially those burning in heavy fuels, are often quite destructive and may kill all trees in a stand.

In lightly defoliated areas fire hazard levels remain low. High hazard levels exist on sites where a substantial number of trees have been killed by insect infestations or disease. Intense, catastrophic fires can result when this kind of hazard is combined with drought conditions or high winds.

Until they decay, limbs, twigs, and needles on the ground increase the rate of spread and intensity of fire. Complete decay of these fine fuels takes about ten years. If fires occur in the large, heavy fuels which cover the severely defoliated areas, suppression will be very difficult. Firelines constructed by hand will be especially troublesome. Large trees on the ground will reduce the effectiveness of fire suppression efforts. Salvage logging and the decay of woody debris will eventually reduce fuel hazards to lower levels.

Effects on Wildfire Potential

Fire is a valuable tool in nature's management of conifer ecosystems. There are many positive ecological effects of both natural and man-caused fires. Wildfires and slash burns, depending on their size, location, and intensity, can quickly provide new forage and cover for many wildlife species. Duff and litter on the forest floor can be reduced by fire, to provide sites suitable for tree planting or natural regeneration.

Fire can also be a destructive force. Large, intense fires can adversely affect soil and water quality. Erosion often results from the removal of vegetation and the protective duff layer. Increased sediment levels in streams produce a direct, adverse effect on water quality. Generally, the effect of wildfire depends on where the fire is, how big it is, and how intensely it burns. High intensity fires can greatly reduce forage and cover for certain wildlife species for long periods of time. Sites which undergo low intensity fires usually produce forage and cover much more rapidly.

When timber stands are defoliated, small quantities of highly flammable materials are produced almost immediately. Twigs and needles accumulate on the forest floor at an accelerated rate following defoliation. This additional material does not normally add an appreciable amount of fuel; but when extensive defoliation occurs over several consecutive years, mortality is a typical result. A significantly greater quantity of fuels will accumulate as larger material dies and trees begin to fall. Fallen trees complicate suppression efforts. Fire intensity is increased where there are concentrations of fallen trees, and hand line construction is slowed significantly in areas which contain these heavy fuels.

Alternative A - No Action

The No Action Alternative would have little effect on fuel loading in areas where only scattered mortality has occurred. However, the extensive defoliation which results in increased mortality would cause a significant rise in fuel loading. Fireline construction would be slower, and firefighter safety concerns would be compounded by the possibility of falling snags and increased fire intensity. Snags, large logs, and beds of needles will have accumulated on the forest floor. Forest fires result when this fuel increase is coupled with dry summers and lightning, or other sources of ignition.

Alternatives B, C, D, and E

Alternatives B, C, D and E would reduce or eliminate the short-term potential for fuel buildup. Only scattered mortality would be expected. Fireline construction would not be slowed, and fire intensity would not increase.

The cumulative effect of increased fuel loading would result from implementation of any of the Alternatives. The No Action Alternative would result in the greatest cumulative effect, because the expected mortality would add significantly to existing fuel levels. Implementation of Alternatives B, C, D, or E would not result in significant increases to existing fuel accumulations. Cumulative effects of spruce budworm defoliation are a special concern. Fuel accumulation levels have a direct impact on fire suppression capabilities. As fuels are added to existing fuel beds, suppression difficulty increases.

Implementation of any of the Alternatives would not conflict with existing fire and fuels plans and policies.

Western Spruce Budworm

Because of uncertainties about western spruce budworm behavior and population dynamics, the ability to effect a lasting reduction in budworm populations is a concern. Gathering precise

information about factors affecting populations before and during an outbreak is a slow and difficult process. The budworm has broad ecological tolerance limits. Each new outbreak provides more information about the budworm and how it interacts with its environment. Such information is of vital importance in developing and selecting management alternatives for managing epidemic populations. When information is lacking, uncertainties must be identified and considered, in order to make the best selection from a range of Alternatives. The following discussion addresses six uncertainties which were identified in the scoping process which began this analysis; the outbreak cycle, reinvasion, resurgence, timing, tolerance, and efficacy:

Outbreak Cycle

Dramatic increases in an insect population can result from a wide range of interrelated factors. A change in weather, food quantity and quality, or biological enemies can, separately or together, cause an outbreak of an insect species. Two conditions which are currently believed to cause epidemic growth in western spruce budworm populations are 1.) an abundant food supply (extensive stands of Douglas-fir and true firs) and 2.) favorable weather (Fellin et al., 1983).

Human intervention in the ecosystem, through timber harvest practices and wildfire suppression, has led to large, contiguous acres of true fir and Douglas-fir (West, 1969; Hall, 1980; Schmidt, 1981). The readily available food source which this provides the budworm, combined with favorable (warm and dry) weather during May, June, and July, can lead to an outbreak (Hard et al., 1980; Ives, 1981; Twardus, 1980). Natural enemies, such as parasites and predators, both vertebrate and invertebrate, apparently exert little control over epidemic growth of budworm populations (Miller and Renault, 1976; Ives, 1981; Campbell and Torgersen, 1982; Torgersen et al., 1984). Natural enemies exert their greatest pressure on budworm populations at endemic levels. Weather and starvation appear to be the most important factors contributing to the decline of an outbreak (Fellin and Schmidt, 1973; Fellin et al., 1983).

There is a remote possibility that insecticide application might prolong the current outbreak or increase the frequency of budworm epidemics in the future. A more realistic concern though, is for the proliferation of spruce budworm host species over large, contiguous areas (Blais, 1983; Fellin, 1983). The philosophy about using insecticides to manage budworm populations has changed; from one which supported ending an epidemic with one application, to one which prescribes several applications to reduce heavy defoliation (Fellin, 1983). The latter strategy allows for an early treatment, which theoretically would result in greater overall benefits. A second treatment is allowed, if necessary, to ensure the expected benefits. The western spruce budworm's food source would be protected by control treatments; but other control mechanisms (such as weather) would serve to ensure the eventual decline and collapse of epidemics, whether or not an area is treated. Niwa et al.(1987), found that two *B.t.* formulations, Thuricide 32LV and San-415 at 20 and 30 BIU/ha, did not affect the percentage of parasitism or species distribution of parasites between *B.t.*-treated plots and controls.

Reinvasion

There is uncertainty of the western spruce budworm's ability to move from previously untreated stands and reinfest treated areas. In the West, the budworm's pattern of short- and long-distance movement is not known. No proven technique or accurate recording method has yet provided the means to study adult moth movement. When disturbed, or when they encounter competing larvae, budworm larvae drop from branches on silken threads. In this way they can be carried by the wind to other trees. Movement by this means is generally over short distances (0 to 500+ feet), depending upon the length of the thread, size of the larvae, distance above the ground, and wind speed (Batzer, 1968). Small larvae which have just emerged from the overwintering stage could be carried for several miles. There is, however, a low probability that this larval "ballooning" is a significant cause of large areas' reinfestation (Batzer, 1968).

It is reasonable to assume that in the absence of substantial geographic barriers or breaks in host-type, adult moths will move freely in their search for host plants. Where DDT was used in past budworm control projects in Oregon and Washington; which accounts for less than 1 percent of the treated areas in these States; treatment resulted in a less than 1 percent need for retreatment because of "reinfestation" (Dolph, 1980). One probable reason for this success is that this persistent chlorinated hydrocarbon insecticide was used over large areas. Few reservoirs of budworm populations remained in the treated areas. In other western regions, the number of areas which were previously treated with DDT more often required retreatment (Fellin, 1983). The treatment of smaller analysis units (AU's) adjacent to infested but untreated areas, and the need for installment of untreated buffer strips along streams and other bodies of water when only chemical insecticides are used; have led to recognition of the possibilities of reinfestation. Largely for this reason, a multiple-treatment scenario

was designed for the Alternatives considered in this analysis. Depending on economic conditions in the year of the outbreak, the analysis may allow for two applications of insecticide in the benefit/cost equation.

Resurgence

The third uncertainty is whether budworm populations, reduced by treatment, will remain at low levels or build back up (resurge) to epidemic numbers. In the Pacific Northwest, insecticide treatment of the western spruce budworm has generally kept populations at acceptable levels for the remainder of the outbreak (Dolph, 1980). One reason for success in previous treatments may be attributable to the use of DDT over large areas in the 1950's. No resurgence was noted in the late 1970's in project areas where carbaryl was used. Where the food source remains available and favorable weather continues, it is reasonable to assume that, given enough time, populations could again increase to epidemic levels. The time required for buildup would be directly related to the treatment's effectiveness. The kind of insecticide that is used, its dosage and coverage, the timing of application, and the weather during and after application are factors which would determine a treatment's effectiveness (Stock and Robertson, 1984). The probability of resurgence is proportional to residual population densities and the impact which treatment has on natural predators and parasites. Suppression efforts which began in 1982 have been monitored closely. It is expected that data compiled from treatment of the current northeast Oregon outbreak since that time will help ameliorate the uncertainty of resurgence. In past outbreaks, treatment usually began 3 to 4 years into the epidemic. During the current outbreak, treatment in some areas was begun in the second year of visible defoliation. With this relatively early treatment, some population resurgence has been found, similar to that which was found in a 1977 budworm control project in New Mexico (Telfer, 1983).

Smirnoff's (1983) biochemical analyses showed that *B.t.* treatments had a detrimental effect on eastern spruce budworm vigor. When sublethal dosages of carbamate and organophosphate chemical insecticides were administered there was a resurgence of vigorous budworm populations. In the East, foliage protection is the objective of budworm suppression rather than population reduction. This strategy may result in more sublethal effects than does the population reduction strategy used in the Northwest and which is considered in this analysis.

Timing

Throughout its range, detectable budworm populations appear to persist indefinitely in stands that contain a substantial proportion of suitable hosts. Populations in these stands have exhibited one of three numerical patterns. The first pattern, chronically high populations, occurs in many stands. According to Johnson and Denton (1975), 14 percent of the outbreaks persisted for at least 9 years, and 35 percent persisted for at least 4 years. In the second pattern, outbreaks may last only 1 or 2 years and result in minimal damage. This accounts for about 48 percent of budworm outbreaks. Persistence at sparse, nondamaging levels is the third numerical pattern.

When visible defoliation is first noted, there is no known way to determine which of the first two patterns the population will take. Therefore, rather than expend resources to protect the forest from an outbreak which may never become damaging, managers prefer to wait until it is likely that populations will become chronically high. Treating early in an outbreak does not prevent "spread" of budworm. Experts believe some environmental factor "releases" budworm from normal controls, resulting in population increases in large areas. The increase is often visible in some areas before it is detectable in others.

Tolerance to Insecticides

The development of population tolerance to insecticides generally requires heavy selection pressure from the repeated use of a particular insecticide. However, selection pressure on only one generation may lead to a greater tolerance in some cases (Robertson and Stock, 1985; McGaughey, 1985). In one study a general pattern of greater population tolerance to carbaryl occurred in areas which had previously been treated with DDT. There were also differences in tolerance to carbaryl associated with prior treatment with a combination of carbaryl and malathion. A shift toward greater tolerance may have occurred in subpopulations of the budworm in sites on the Okanogan and Boise National Forests; where carbaryl, or both carbaryl and malathion had been applied. Where fenitrothion, malathion, and carbaryl were applied in successive years, no greater tolerance was found than in previously untreated areas.

It is generally considered difficult for insects to develop resistance to microbial insecticides, such as *B.t.*, because of their complex modes of action. One report, however, indicates that *Plodia interpunctella*, a lepidopteran pest of stored grain, has developed

resistance to commercial formulations of *B.t.* within a few generations (McGaughey, 1985). The report indicated the stored grain environment provided an ideal situation for resistance development. To develop a similar resistance in a field crop environment would require repeated applications over a wide geographic area for several years. Such a situation has not existed where western spruce budworm treatments have been effected in the Northwest.

Efficacy

Aerial application of insecticides is very complex because there are so many variables that are uncontrollable. Differences in elevation, slope, and aspect result in varying times of insect and foliage development over an area. This sometimes makes it difficult to prescribe the time an area should be sprayed. The foliage must be expanded in order to present a surface for spray droplet deposition. The insect must be developed to a stage where it is freely feeding and exposed to the spray deposit before the deposit degrades and is not useful. Weather and atmospheric conditions must be within certain limits in order to effectively atomize the insecticide formulation from the aircraft and allow its movement to the forest canopy. Careful attention to each of these variables increases the probability of budworm larvae consuming a lethal dose of insecticide.

In the 1982 Budworm Suppression Project, budworm populations were below the target level of 7 larvae/100 buds in carbaryl-treated areas 14 days after treatment. Post-treatment populations, averaging 9.1 larvae/100 buds in acephate-treated areas, did not meet the targeted level (Hostetler, 1983). Since acephate is a water-soluble formulation, rain showers within 1 day after treatment may have removed some of the toxicant from the target foliage in some areas. In other areas, where rain was not a factor, other conditions may have affected the quality of spray application and produced the undesirable results.

Defoliation sampling was conducted during 1983 at many of the larval population sampling sites within 1982 treatment units. In the carbaryl-treated units, the overall defoliation was light in one unit, light to moderate in two, and moderate in one. Defoliation in the acephate-treated unit was heavy. An untreated unit showed extremely heavy defoliation.

On approximately 525,000 acres which were treated with carbaryl during 1983, larval sampling 2 to 3 weeks after insecticide application showed budworm populations to have been reduced to below the target level of 1.5 larvae per 45-cm branch tip on about 80 percent of the units treated (Bridgwater, 1983). The 1.5 larvae-per-branch-tip target is equal to about 4.5 larvae per 100 buds--the unit of measure used in 1982. While population levels were greatly reduced on the remaining 20 percent of the treatment units, they remained above the target level, which was between 1.7 to 3.3 larvae per 45-cm branch tip. These higher population levels may have been due to problems with application rather than insecticide ineffectiveness.

The 1987 suppression projects had mixed results. Of the three units treated with *B.t.* (North and South Units on the Malheur National Forest and Rimrock on the Wenatchee National Forest), the Rimrock Unit was the most successful. On the Rimrock unit, all contracted acreage (44,000) was treated, spray deposit was acceptable, and the population density was reduced to 0.89 ± 0.10 budworms per 45-cm branch tip. There were no significant problems of application, administration, or contractual compliance.

The North and South Units on the Malheur National Forest will be discussed as one. Because of administrative and contractual problems, only 94,000 of the 204,000 acres under contract were treated. Of those acres treated, 34,500 had budworm population densities reduced to 1.11 ± 0.19 budworms per 45-cm branch tip, barely meeting the threshold value of 1 larva per branch tip. Spray deposit was judged as marginally acceptable over those acres. Treatment over the remaining acreage was considered unacceptable. Unacceptable spray deposit was determined to be caused by poor formulation of the product.

Small areas on the Ochoco and Malheur National Forests were treated with *B.t.* in 1984 and 1985, to determine the cost-effectiveness of various formulations and application techniques. The 1984 test confirmed that 12 billion international units (BIU's) per acre is more effective than 8 BIU's per acre; and that application with small helicopters using rotary atomizer spray nozzles which produce relatively small droplets (i.e., mass median diameters of 100 to 125 microns) is desirable. Population reduction to below 1.5 larvae per 45-cm branch tip was reached on about 75 percent of the treated plots (Beckwith, Stelzer, and Hostetler, 1984). In 1985, an operational evaluation was conducted on the Malheur National Forest, to determine if *B.t.* could reduce budworm populations to or below 1 larva or pupae per 45-cm branch tip. The evaluation did not document significant differences in treatment results. All were considered successful. A helicopter application of Thuricide 32LV, 16 BIU's per acre, applied at 64 fl. oz. per acre, resulted in the lowest density of surviving larvae and pupae. This reduced survivors to 0.37 per 45-cm branch tip (Ragenovich, 1986).

In 1988, a major set of suppression and developmental projects was conducted in Oregon to deal with the current spruce budworm outbreak. The threshold for a successful post-treatment population reduction, established in 1987, was less than 1 larva/45-cm branch tip. This level is achievable when good applications are made, as was shown in the 1985 special evaluation. The level is not only related to the insecticide used, but also to the quality of the application and the administration of the project. Biologically, it is also desirable to reduce budworm populations to nearly undetectable, endemic levels so normal processes will again exert control.

Operational units on the Mt. Hood National Forest recorded the following post-treatment results: Dalles, 2.40±.36 larvae/45-cm branch tip within an area of 116,000 acres; Barlow, 0.56±.07 larvae/tip within an area of 140,000 acres; and Warm Springs, 0.57±.08 larvae/tip within an area of 186,000 acres. The Dalles units did not meet the predetermined threshold for acceptable post-treatment population densities. This may have been due to poor application within portions of the unit. In addition, there were very high populations of budworm in some areas of the unit.

Units within the Umatilla National Forest's Tollgate project yielded the following post-treatment results: 0.55±.09 and 0.68±.14 larvae/45-cm branch tip over approximately 107,000 acres, and 1.42±.38 larvae/tip over approximately 2,000 acres. One unit not meeting the threshold of 1 larva/tip was thought to have received a poor treatment.

Projects conducted by Longview Fiber (a wood products company) and Hood River County used both carbaryl and *B.t.* Over an area of 33,000 acres, carbaryl reduced populations to an average of 0.49 larvae/45-cm branch tip. *B.t.* gave variable results over 6,700 acres, resulting in an average of 2.32 larvae/tip. Results may differ due to variations in spray deposit. The average deposit on carbaryl spray deposit cards was 25 drops/square centimeter, whereas the *B.t.* averaged 14 drops.

The Boise Cascade Corporation conducted a small-scale project near Elgin, Oregon, using carbaryl. Over an area of approximately 10,000 acres, populations were reduced to 0.17 larvae/45-cm branch tip.

In a pilot project conducted near Meacham, Oregon, to determine the feasibility of using undiluted formulations of *B.t.* at 43 oz.(16 BIU)/acre, the following post-treatment results were obtained: Dipel 6AF, 2.17 larvae/45-cm branch tip, 87.8 percent population reduction; Thuricide 48LV, 1.03 larvae/tip, 94.7 percent population reduction; and the control 7.83 larvae/tip, 54.7 percent population reduction. These are preliminary results; however, it appears that only Thuricide 48LV was close to meeting the criterion of reducing the population to less than 1 larva per tip.

A special project was conducted on the Mt. Hood National Forest to determine the handling and application effectiveness of two formulations of *B.t.* Dipel 6L was applied undiluted at 43 oz. (16BIU)/acre, and Thuricide 32LV was applied undiluted at 64 oz. (16BIU)/acre. Preliminary results indicate both formulations reduced populations of budworm to below the 1 larva/45-cm branch tip threshold. Thuricide 32LV reduced populations to 0.28±.08 larvae/tip, a 94.0 percent population reduction. Dipel 6L reduced populations to 0.90 larvae/tip, a 90.4 percent population reduction.

From the preceding, it became apparent that under the conditions of these projects there is no practical difference between the short-term population reduction efficacy of carbaryl and *B.t.*. Either can reduce populations to less than 1 larva/45-cm branch tip, given proper application and effective project administration. There are, however, potential differences which may make one insecticide more desirable than the other in effecting long-term suppression of budworm populations.

An insecticide with both contact and stomach toxicity modes of action provides more flexibility in timing applications. For instance, volatile properties of a contact insecticide can kill early instar budworm larvae that are protected by webbing from ingesting stomach poisons. If not killed, some larvae become so agitated that they become easier prey for natural enemies or are otherwise lost from the defoliating population. Also, if applications are delayed, a contact insecticide can kill late instar larvae that have already stopped feeding and are not susceptible to stomach poison. Theoretically, an insecticide with both contact and stomach poisons would offer a wider application window. Carbaryl has both contact and stomach poison properties, while *B.t.* has only the stomach poison.

The residual activity of an insecticide formulation on the target surface, in this case tree foliage, determines in part how useful it is. A foliage residue of 2.74 parts per million was found after spraying with 0.5 lb. carbaryl/acre for spruce budworm control in Minnesota. This level declined to 1.14 ppm after 10 days (Millers, 1976). When 1.0 lb. carbaryl/acre was applied to control spruce budworm in Maine, an immediate post-spray foliage residue of 1.99 ppm was recorded. A residue of 1.12 ppm was found after 14 days, and after 28 days, no detectable residue (0.02 ppm) remained (LOTEL, 1977). Carbaryl is thought

to have approximately a 10- to 14-day half-life, or practical insecticidal life, on host tree foliage in the Northwest. Early work on formulations of *B.t.* showed that most insecticidal effectiveness had disappeared after 3-4 days (Beegle et al., 1981; Ignoffo et al., 1974). A study of two accepted formulations of *B.t.* in the forested environment (Beckwith and Stelzer, 1977) suggests that degradation is not that rapid. The time to reach 50-percent of the original effectiveness (for both strains) exceeded the 10-day sample. Values of 13.9 and 44.2 days for 30 BIU/ha were calculated for SAN-415 and Thuricide 32LV, respectively. From this information, it is inferred that accepted *B.t.* formulations have at least a 14-day practical insecticidal life on host tree foliage in the Northwest. *B.t.* has the potential for longer activity in the target budworm population and in following generations (Klein and Lewis, 1966; Morris, 1977; Smirnoff, 1979). Some of the variation in budworm control documented in past studies could be related to the slower action of the bacteria in causing insect mortality; that is, some mortality may have occurred after measurements were taken. Stipe et al., (1983) records some carry-over effects after the first year of treatment. These effects, while observed, have not been explained. Larvae that are parasitized are usually more sluggish and do not feed as much as larvae that are free of parasites (Lewis, 1960; Leonard and Simmons, 1974; Hamel, 1977). This results in budworm remaining in the larval stage longer, where they are more likely to be found by predators.

The above information suggests there may be little difference between carbaryl and *B.t.* formulations in the measured persistence of practical insecticidal residue. The beneficial effects of *B.t.* applications may carry over to subsequent years; however, no research has been conducted which fully documents or explains their occurrence.

The initial effects of insecticides and their subsequent residual effects may not only produce desired results on the target organism, in this case the budworm; but may also affect non-target organisms. Some nontarget organisms are beneficial; natural enemies of budworm. While these organisms are not thought to be significant in reducing outbreak populations, they are known to cause significant mortality in endemic populations. If their populations are damaged during suppression projects, they may be unable to effectively control budworm populations when suppression efforts have returned the latter to endemic levels. Without such controls, budworm populations may rebound to epidemic levels. Carbaryl is a broad-spectrum insecticide having both contact and stomach toxicity properties, and has also demonstrated a relatively long persistence on forest tree foliage.

In 1983, during a budworm suppression project using 1 lb. carbaryl/acre, possible effects on the foraging activity of predaceous ants were examined. Foraging activity was reduced for at least 6 weeks, effectively negating their activity against that generation of budworm. Two species were not found in the spray areas, whereas they remained in the untreated control areas and increased in density. No work was done after the sampling taken 6 weeks after spraying.

Carbaryl may have a slight direct toxic effect on some bird predators, as well as an indirect effect of reducing insect prey species. *B.t.* has insecticidal effects only on certain lepidopterous species that are feeding on the sprayed foliage when the residue is at insecticidal levels.

Alternative A - No Action

Implementation of the No Action Alternative would not result in lasting reductions in budworm populations. If the No Action Alternative were selected, the outbreak would be allowed to run a natural course of rise, peak, and decline. Weather, parasites and predators, disease, and food supply would be allowed to exert their normal influence over the outbreak populations. Implementation of this Alternative would not preclude the long-range prevention of budworm outbreaks through current and future forest management practices.

Alternative B

Applying *B.t.* is not considered likely to prolong the outbreak. Application should have no effect on natural enemies. When populations of budworm are suppressed, the natural enemies should be able to again exert their controls.

Reinvasion from untreated buffer strips within the treatment areas would not be a problem because no buffer strips are required.

Resurgence is expected to be less of a problem under this Alternative than under Alternatives C and D, because *B.t.* would not stimulate vigorous population growth if areas receive sublethal doses.

The use of *B.t.* would not affect the timing of treatment applied to damaging populations.

It is unlikely that budworm populations would develop a tolerance to *B.t.* applications.

Quality *B.t.* applications would be likely to suppress budworm populations to below the established threshold density of 1 larva per branch tip. *B.t.*'s mode of action is that of a stomach poison. It has a useful life on foliage of at least 14 days.

Alternative C

Applying carbaryl would not likely prolong the outbreak, and would have only minor effects on the budworm's natural enemies. Predator populations would be expected to recover in time to exert their controls and prevent further resurgence.

Reinvasion from untreated areas would be a potential problem, because untreated buffer strips would serve to protect streams and other bodies of water from contamination by significant amounts of insecticide. In some instance these buffer strips could be quite wide; allowing for large infestations of budworm to remain untreated.

Resurgence is a potential problem with the use of carbaryl. In New Mexico, and also to a lesser extent in Oregon during the current outbreak, resurgence may have been caused by application of sublethal doses. Such application can stimulate vigorous population growth.

The use of carbaryl would not affect the timing of treatment of damaging populations.

Studies show budworm populations can develop a tolerance to carbaryl applications.

Quality carbaryl applications would be likely to suppress budworm populations below the established threshold density of 1 larva per branch tip. Carbaryl's mode of action is that of a stomach and contact poison. It has a useful life on foliage of 10 to 14 days.

Alternative D

The option of using either *B.t* or carbaryl would allow managers to select the one which best meets the needs of a particular situation. When there is no practical difference, or no concern about potential effects, the choice could be made for economic or other reasons.

Alternative E

Implementation of this Alternative would result in effects similar to those described under Alternative B. The primary difference between these two Alternatives is that under Alternative E carbaryl could be used, but only in very limited instances.

Wildlife

Alternative A - No Action

Depending upon extent and severity, budworm-caused timber stand defoliation has the potential to adversely affect big-game habitat. Rocky Mountain elk and mule deer use timber stands as hiding and thermal cover. These stands, if substantially affected by spruce budworm defoliation, could lose many of the characteristics of cover. Overstory canopy closure is normally not substantially affected in most defoliation areas. Spruce budworm defoliation is most characteristically in the uppermost reaches of the canopy. The most common result is the canopy depth is reduced. However, thermal cover values are expected to remain essentially the same. Although some hiding cover would be lost, the amount would not be great, and increased forage production in the affected areas could compensate for cover losses when determining overall habitat effectiveness. We feel no economic values could be assigned to these cover losses due to the offsetting factors. Economic evaluations of budworm impacts upon big game hiding cover in Montana have been included in a recent environmental assessment on the Gallatin National Forest. Review of that process indicates, because of differing stand characteristics and basic assumptions about tree mortality in the Oregon and Washington infestations, the process used in Montana is not considered applicable to this EIS.

Extensive, long-duration spruce budworm infestations provide insectivorous birds and mammals an abundant food supply. Localized areas are expected to experience population increases in some species in response to this abundant forage. It is not known whether the total predator populations respond proportionately to increased budworm numbers, or whether individuals are drawn into an area by greater foraging opportunities. Arthropod predators of spruce budworm also find abundant prey. There is no indication these predator populations respond proportionately to the increased availability of spruce budworm as prey.

Spruce budworm infestations, and resultant top-kill and tree mortality, provide slight benefits to cavity-nesting species and those species using spike tops as perches because tree mortality usually occurs in trees less than 10 inches diameter at breast height (DBH). These small-diameter trees are, most often, unsuitable nesting sites for cavity nesters.

Taking no action, and allowing continued spruce budworm infestation, will result in minor reductions of hiding and thermal cover for big game. Offsetting these losses will be an increase of forage production associated with reduced tree crown cover. Both effects are expected to be of little consequence.

Beneficial effects include slight increases in nesting habitat for cavity nesters and perches for raptors as a result of tree mortality and top-kill. Abundant insect populations are also beneficial to insectivorous wildlife species. Benefits of abundant forage are

transitory, lasting only as long as the current infestation.

Overall, it appears general wildlife populations benefit slightly from the current spruce budworm infestation. Benefits are transitory and are not expected to last much longer than the infestation.

Alternative B

Impacts upon wildlife result primarily from increased human activity associated with treatment projects. Coverage of large areas by personnel and equipment increases the disturbance factor. Species sensitive to this type of disturbance, such as bald eagles, golden eagles, ospreys, and spotted owls, nest in some affected areas. Nest abandonment because of disturbance by low-flying aircraft or activities of ground personnel could occur. Concerns about disturbance effects on deer, elk, and bighorn sheep have been raised; for instance, lactating mothers may abandon their young.

We felt the potential for such an effect exists, but due to the limited duration of disturbance in each spray block, significant impacts were unlikely.

Field tests have not revealed any deleterious effects of *B.t.* on populations of birds and mammals. Studies in Algonquin Park and Spruce Woods in Canada, found no significant difference between populations of birds and mammals on sprayed plots versus populations on untreated plots (Buckner et al., 1974). In a second test, aerial application of *B.t.* (Dipel WP) applied at a rate of 0.5 lb./acre to a Scotch pine plantation containing a large population of nesting mourning doves, apparently did not affect or disturb the birds (Kearby et al., 1975). Twenty-four hours after spraying, nestlings were observed still in their nests and adults were flying about the plantation. After 28 days, adults were still numerous and nestlings had fledged. A study to determine secondary effects of *B.t.* spray on chickadees was done during the 1986 Gypsy Moth Project in western Oregon (Gaddis and Corkran, 1986). Spray areas were treated three to four times with 16 to 20 BIU's per acre. Results indicated there was a significant difference in the number of lepidoteran caterpillars available for food between treated and untreated areas; however, this did not affect success of the chickadee reproductive process or fledgling development; chickadees simply found other food. There was no significant difference in time spent foraging for food between treated and check areas. In another study conducted by the Oregon State Fish and Wildlife Department, clutches of pheasant eggs received simulated applications of *B.t.* spray. There was a significant decrease in egg hatch between treated and nontreated eggs. *B.t.* applications with and without the enzyme, chitinase, had no detectable impact on small mammal abundance (Buckner et al., 1974). Field mice (*Napaeozapus insignis* Miller and *Peromyscus maniculatus* Wagner), shrews (*Blarina brevicaudia* and *Sorex cinereus* Kerr), voles, and chipmunks (*Tamias striatus* L.) were examined. Eighty percent of a small sample of adult females had placental scars, indicating that reproduction was unaffected.

Except for lepidopterans, no toxicity to zooplankton, arthropods, fish, birds, mammals, and other wildlife or domestic species, has been demonstrated at levels recommended for field application. In fact, only extremely high concentrations (such as might occur with a spill) have demonstrated any effect.

Livestock operators have expressed concern regarding the use of bacteria in areas where livestock graze. *B.t.* has been identified only once as a pathogen in mammals (causal agent in a case of bovine mastitis). Whether other factors were involved in this case is not known (USDA Forest Service/Animal and Plant Health Inspection Service, 1984).

Evidence from laboratory testing on effects to domestic species found *B.t.* produced no adverse effects, and even if ingested in large quantities, will not survive in the animal's digestive system. Regulatory agencies have placed no restrictions on the use of *B.t.* near livestock or food crops. *B.t.* has been widely used to control insect pests other than western spruce budworms. *B.t.* is a lepidoptera-specific insecticide; therefore, only phytophagous insects in the Order Lepidoptera (butterflies and moths) are affected. In field tests in Nova Scotia, where *B.t.* was the only insecticide applied to an apple orchard over a 4-year period, population levels of lepidopterous insects were reduced, but there was no observed effect on predaceous insects (Jaques, 1965).

Spruce-fir stands in Algonquin Park, Ontario, Canada, and mixed forest containing mature spruce stands, poplar bluffs, and areas of dense brush and open fields in Spruce Woods, Manitoba, were sprayed with formulations of Thuricide 16B or Dipel WP (trade names of *B.t.* formulations). Although some declines in populations of nontarget insects were observed, comparison with the controls indicated the declines could not be attributed to the spraying (Buckner et al., 1974). These studies also reported no significant increase in mortality among foraging bees as a result of *B.t.* treatment. Other studies of the effects of *B.t.* on honey bees (Krieg, A.,& W. Herts, 1962; Krieg, A.,& W. Herts, 1963; Burges and Bailey, 1971; Franz et al., 1967; Cantwell et al., 1966; Wilson, 1962) found no evidence these insects would be harmed by *B.t.* at the levels commonly used in spray operations.

B.t. has been shown to be nontoxic to bees at levels as high as 726,000 spores per bee (Atkins et al., 1975).

One study has shown *B.t.* to be fatal to earthworms at concentrations 104 to 105 times higher than that which would occur in the soil after normal application in the field (Smirnoff and Hempel, 1961). However, these studies were carried out using *B. thuringiensis* var. *thuringienesis,* a producer of beta-exotoxin which could have influenced the results. Experiments using Dipel (16,000 International units/mg) at dose rates of 60, 600, and 6,000 mg/square meter on forest plots, and Bactospeine (1,000 IU) at a dose rate of 30 g/cubic meter, show worm density after spraying was not significantly different from worm density prior to spraying (Bentz and Altwegg, 1975). The formulations considered for use against spruce budworm contain a variety of the *B.t.* bacterium that does not produce beta-exotoxin.

Other concerns associated with a *B.t.* spray project center around the impacts upon nontarget lepidopterans, and the impact a reduction of lepidopteran populations will have upon species that prey upon these insects. Many butterflies and moths will have pupated or completed metamorphosis prior to the proposed early summer budworm treatment period. Only those phytophagous larvae that feed on external plant parts will be susceptible to *B.t.* Those insects that feed inside plants, such as borers, needle miners, and gall moths, will not be affected. Additionally, under the most favorable conditions for control, a percentage of insects, even target species, survive control efforts. In a study done during the 1986 Gypsy Moth Project in western Oregon, it was found the population of lepidopteran larvae was reduced significantly within 48 days following the last treatment. However, there was no significant difference between populations in the control and treated areas 68 days following the last treatment (Miller, 1986). Considering these combined factors, it is highly unlikely that significant long-term impacts upon nontarget lepidopteran populations will occur.

Since *B.t.* is not a broad-spectrum insecticide and affects only lepidopterans (moths and butterflies), expected impacts upon terrestrial organisms are slight. Most beneficial insects would not be affected. Some nontarget moth and butterfly species, which are in the larval stage at the time of treatment, may be at risk of experiencing population reductions for a year or two. Insect populations representing food supplies for birds would not be appreciably affected, so the risk of nest abandonment would be slight.

Implementation of Alternative B would result in minimal disturbance of wildlife populations, and would have little adverse impact to survival and abandonment of young. Mitigation measures controlling the timing of treatment and no-treatment buffer zones around critical areas such as bald eagle nests or bighorn lambing areas, will minimize disturbance.

A number of vertebrate wildlife species will be exposed to some level of *B.t.* under this alternative. Species, including those of special interest that are known or suspected to occur in at least one analysis unit, are listed in Table IV-I. None of these species will experience serious adverse effects as a result of exposure to *B.t.*

Alternative C

The risk to wildlife species from spruce budworm suppression with carbaryl is a function of the inherent toxicity (hazard) of the insecticide to different organisms, and the amount of chemical ("dose") those organisms may take in as a result of a spraying operation. The wildlife species risk analysis compares estimated acute exposures of representative species with acute toxicity levels found in laboratory studies.

For wildlife risks, the criteria used by the Environmental Protection Agency (EPA, 1986) in ecological risk assessments were used to judge absolute risks to the different representative species. The EPA criteria compared an estimated environmental concentration (EEC) with a laboratory-determined LD_{50} for the most closely related laboratory test species. (See Glossary for a definition of LD_{50} and LC_{50}).

Where the EEC exceeds 1/5 LD_{50} or LC_{50}, but is less than the LC_{50} or LD_{50}, EPA deems it a risk that may be mitigated by restricting use of the pesticide. EPA judges EEC's that exceed the LD_{50} or LC_{50} as significant, unacceptable risk levels. Doses below the 1/5 LD_{50} level are assumed to present a low or negligible risk. In this risk assessment, an organism's total estimated dose (rather than an EEC) is compared with the laboratory toxicity level to include exposures from all possible routes, including oral, inhalation, and dermal exposures.

Analysis of insecticide risk to wildlife compared estimated acute doses for the representative wildlife species with available hazard information on the most closely related species. Because carbaryl showed no tendency to bioaccumulate, long-term persistence in food chains and subsequent toxic effects, such as those resulting from use of persistent organochlorides, are not considered a problem and are not examined in the risk analysis. No analysis of chronic wildlife dosing was done because the insecticide degrades relatively rapidly and sites are normally treated not more than

Table IV-I

Representative Wildlife and Domestic Species

Representative Niche	Representative Species
Insectivorous birds Granivorous birds Omnivorous birds Piscivorous birds Carnivorous birds	Flicker Dove Jay Kingfisher Owl
Small omnivorous mammals Medium herbivorous mammals Large herbivorous mammals Carnivorous mammals	Mouse Rabbit Deer Fox
Insectivorous amphibians	Toad
Carnivorous reptiles	Snake
Domestic animals	Cattle Chicken Dog

once during any season or twice during any outbreak period.

Alternative D

It is assumed *B.t.* will be applied on sensitive areas, e.g., riparian/watershed, and carbaryl will be used on all other areas. The most substantial difference between this alternative and the carbaryl-only alternative is the reduced impact on the aquatic ecosystem.

Alternative E

The biological insecticide *B.t.* is the treatment of choice. Wildlife impacts should be minor, essentially the same as for Alternative B. If use of carbaryl is warranted, the effects on wildlife would be similar to those expected under Alternative D.

Wildlife Risk Assessment

The estimation of risks to wildlife species consists of three components -- hazard, exposure, and risk analysis. The hazard analysis consists of a review of available toxicity information on a chemical to determine median lethal doses -- LD_{50}'s -- for the representative wildlife species. These species were chosen to represent a range of phylogenetic classes and types of exposure. They are listed in Table IV-I. The exposure analysis calculates doses of the insecticide to these species. The risk analysis compares the doses to the LD_{50}'s to evaluate risk.

Hazard Analysis

This is a brief summary of toxicity data on carbaryl and the petroleum distillates diesel oil and kerosene. A detailed review can be found in section 2 of Appendix F.

Carbaryl

Carbaryl is considered moderately toxic to mammals, with LD_{50}'s ranging from 50 mg/kg to 70 mg/kg. Several field studies have examined its effect on wildlife populations when applied at various application rates. The carbaryl application rate in the spruce budworm control program is 1.0 lb a.i./acre. A study of an area treated with 1.25 lb a.i./acre of carbaryl reported no adverse effects on small mammals or deer. Treatment of a forest at 4.46 lb a.i./acre led to a reported decrease in mole and rodent populations, with no recovery after 2 years. Treatment of a field with 2 lb a.i./acre caused a decline in cotton rat populations, an increase in house

mouse populations, and no change in field mouse populations.

Carbaryl is considered slightly toxic to birds, with LD_{50}'s ranging from 780 mg/kg to more than 2,500 mg/kg. A number of studies have reported no effects on bird populations in areas treated with carbaryl at rates up to 5 lb a.i./acre, but several have reported decreased cholinesterase levels in birds. One study reported significant declines in bird populations, possibly resulting from reduced food supplies followed by migration to other areas. Extensive use of carbaryl may cause a substantial reduction in the reproductive success of avian species, especially quail and pheasant.

Carbaryl is very toxic to honey bees. The LD_{50} for an adult bee exposed by direct contact is approximately 1 mg, or 10 mg/kg. Older bees are less susceptible, but may carry contaminated pollen to the hive before they sicken or die. If bees are removed out of an area to be treated and not returned for 7 days after spraying, mortality is not significant.

Because carbaryl acts as a broad-spectrum insecticide, a certain amount of mortality to a wide variety of insects and other arthropods may be expected.

Diesel Oil

The major hazards to mammals from diesel oil in the environment are the adherence of oil to the fur of animals, possibly resulting in hypothermia, and sublethal effects in small mammals from contaminated forage.

Diesel oil is very slightly toxic to orally exposed birds, but may significantly affect reproduction success.

Diesel oil appears to be highly toxic to honey bees, suggesting the potential for a high degree of toxicity to other invertebrates.

Kerosene

Little toxicity information is available on kerosene risks to wildlife. One study showed that it was not lethal to embryos when applied to mallard eggs at doses up to 50 ml/egg.

Exposure Analysis

Doses to the representative wildlife species were calculated for typical and worst case scenarios. A detailed discussion of the methods and assumptions is presented in section 3 of Appendix F.

The wildlife risk assessment tends to overstate risks and many assumptions are quite conservative. For example, no degradation is assumed to occur, and all pesticide sprayed is assumed to be biologically available. In worst-case exposures, the entire diet of an animal is assumed to consist of contaminated items, while in the typical scenario a significant percentage of the diet is assumed to be contaminated. Dermal exposures are assumed to come directly from pesticide spray, and indirectly, from brushing up against treated vegetation. Birds and mammals receive dermal doses through their skin and from grooming. This accumulation undoubtedly overestimates doses, even in realistic cases. Nevertheless, when dose estimates exceed the EPA risk criterion, and more so, when they exceed the LD_{50} for the most closely related laboratory species, there is a clear risk of adverse effects on individual animals.

Risk Analysis

None of the representative wildlife species are at risk from carbaryl application in the typical scenario. Worst-case exposures may adversely affect small mammals, amphibians, and reptiles, since these doses exceed the EPA risk criterion of 1/5 LD_{50}. However, even these extreme doses do not approach or exceed the LD_{50}'s. The reproductive capacity of these species is generally high enough to replace those lost within the next breeding cycle. Populations of larger mammals and birds, and any domestic animals present, are not likely to be affected at all.

Bird eggs or nestlings exposed to insecticides or diesel oil and kerosene, would result in some risk of death or injury. Nestlings would get a dermal dose depending upon how well the nest was protected, and an oral dose depending upon the amount of residue deposited on their food items. Bird eggs are far less likely to be affected by insecticides because they are not likely to be left uncovered during a spray operation. The parents' body would protect eggs from direct deposition, although a minor amount of insecticide might reach the egg via the feathers of either parent during incubation. Diesel oil and kerosene present some risk to bird eggs by penetrating the shell more easily than water-based insecticides, and are both relatively toxic to developing embryos. The eggs are not likely to receive an appreciable amount of these chemicals since they are normally protected by an incubating adult.

There are very few studies on which to base conclusions regarding toxicity levels. However, the conservatism used in estimating wildlife doses should compensate for much of the uncertainty in the toxicity data base.

Risks to wildlife from carbaryl, diesel oil, and kerosene used in spruce budworm suppression are shown in Tables IV-II, IV-III, and IV-IV.

No realistic doses of carbaryl exceed the EPA risk criterion of 1/5 LD_{50}. Alternative C would not present a substantial risk to wildlife populations.

Table IV-II

Carbaryl Wildlife Risk

Representative Species	Realistic Dose (mg/kg)	Extreme Dose (mg/kg)	1/5 LD_{50}	LD_{50}	Reference Species
Flicker	6.1	31.0	156	780	Grouse
Dove	5.2	26.0	156	780	Grouse
Jay	6.4	32.0	156	780	Grouse
Kingfisher	4.3	19.0	156	780	Grouse
Screech owl	8.3	41.0	156	780	Grouse
Mouse	15.4	77.0	55	275	Mouse
Rabbit	2.8	17.0	142	710	Rabbit
Deer	0.52	3.8	40	200	Mule deer
Fox	1.9	9.6	30	150	Cat
Toad	40.0	200.0	156	780	Grouse
Snake	52.0	260.0	156	780	Grouse
Cow	0.32	3.6	40	200	Mule
Chicken	1.4	6.9	156	780	Grouse
Dog	0.79	3.9	30	150	Cat

Table IV-III

Diesel Oil Wildlife Risk

Representative Species	Realistic Dose (mg/kg)	Extreme Dose (mg/kg)	1/5 LD_{50}	LD_{50}	Reference Species
Flicker	4.0	40.0	3,280	16,400	Mallard
Dove	3.3	33.0	3,280	16,400	Mallard
Jay	4.2	42.0	3,280	16,400	Mallard
Kingfisher	1.9	19.0	3,280	16,400	Mallard
Screech owl	5.5	55.0	3,280	16,400	Mallard
Mouse	11.0	110.0	1,476	7,380	Rat
Rabbit	1.6	21.0	1,476	7,380	Rat
Deer	0.20	4.3	1,476	7,380	Rat
Fox	1.0	10.0	1,476	7,380	Rat
Toad	12.0	120.0	3,280	16,400	Mallard
Snake	15.0	150.0	3,280	16,400	Mallard
Cow	0.15	4.9	1,476	7,380	Rat
Chicken	0.63	6.7	3,280	16,400	Mallard
Dog	0.30	2.9	1,476	7,380	Rat

Table IV-IV

Kerosene Wildlife Risk

Representative Species	Realistic Dose (mg/kg)	Extreme Dose (mg/kg)	1/5 LD_{50}	LD_{50}	Reference Species
Flicker	1.1	12.0	3,300	16,400	Mallard
Dove	0.93	9.5	3,300	16,400	Mallard
Jay	1.2	12.0	3,300	16,400	Mallard
Kingfisher	0.54	5.5	3,300	16,400	Mallard
Screech owl	1.6	16.0	3,300	16,400	Mallard
Mouse	3.2	32.0	5,600	28,000	Rat
Rabbit	0.45	6.1	5,600	28,000	Rat
Deer	0.062	1.2	5,600	28,000	Rat
Fox	0.29	3.0	5,600	28,000	Rat
Toad	3.3	34.0	3,300	16,400	Mallard
Snake	4.2	43.0	3,300	16,400	Mallard
Cow	0.043	1.4	5,600	28,000	Rat
Chicken	0.18	1.9	3,300	16,400	Mallard
Dog	0.084	0.84	5,600	28,000	Rat

Wildlife exposures are far below the EPA risk levels for diesel oil and kerosene and, under this program, there would be no risk to wildlife populations from their use.

Cumulative Effects (Wildlife)

Alternative A - No Action

There is potential for substantial local impact on deer/elk cover directly related to spruce budworm.

The substantial impact on cover would result from long-term spruce budworm infestation, combined with increased tree mortality due to complicating factors such as drought and Douglas-fir beetle.

Alternative B

No substantial adverse cumulative effects are expected.

Alternative C

The extent of the adverse effect is not known at this time. The impact would be indirect because carbaryl is not persistent and does not accumulate. The cumulative effect, primarily on invertebrates, would be greater than the effects of Alternatives A or B. However, the effects are probably not substantial.

Alternative D and E

The cumulative effects are the same as for Alternative C.

Range

Alternative A - No Action

No detrimental effect on range resources would be expected from the current spruce budworm outbreak.

Alternative B

A locally substantial impact on range resources could result from implementation of this Alternative (the use of *B.t.*). The impact would be on noxious weed control. Biological control agents are major factors for control of noxious weeds in parts of Oregon. For example, the cinnibar moth (*Tyria jacobaeae*), a lepidopteran, is used as one agent for controlling Tansy ragwort (*Senecia jacobaea*). *B.t.* is relatively specific in its impact on lepidopterans. Close

coordination with County weed control agencies and the Oregon State Department of Agriculture would be needed, to mitigate any potential local impact. It is possible that spruce budworm and cinnibar moth populations may not be susceptible to *B.t.* effects at the same time.

Alternative C

This Alternative, in proposing to use only carbaryl in infested areas, has the greatest potential of all action Alternatives to have significant local effects on range resources. The effect would be directly on noxious weed control biological control agents. Carbaryl would be detrimental to populations of most insects which are used in biological control of noxious weeds. The impact would be substantial in Oregon; where the State Department of Agriculture, in cooperation with County weed control boards, Forest Service, BLM, BIA, etc., operates an aggressive noxious weed control program.

Alternative D and E

The impact of either of these Alternative could be locally significant on range resources. The major effect would be potential loss of nontarget insects, specifically those species which are used as biological control agents on noxious weeds.

Mitigating Measures

Close coordination with County weed control agencies and the Oregon State Department of Agriculture would be needed, to mitigate any potential impact to local cinnabar moth populations.

Threatened, Endangered, And Sensitive Species

Alternative A - No Action

This alternative would have no known negative impact to threatened and endangered species.

Defoliation of northern spotted owl habitat by western spruce budworm is not considered to be a substantial negative impact. Current year defoliation would occur primarily after the period when adult birds breed. They would be least mobile at this time. However, as the summer progresses and defoliation increases, juveniles and adults could readily move out of an affected area. A long-term effect of defoliation could be an increase in top-kill. This in turn could result in an increase in broken tops which can serve as nesting/roosting sites for the owl.

Alternative B

This Alternative has potential to impact threatened, endangered and sensitive plant and animal species in a limited manner. The potential for direct impact would probably result from mechanical activities associated with the aerial application of *B.t.*

Bald eagle nesting territories are known to exist in areas of potential treatment within Region 6. Mitigating measures have been developed in cooperation with the U.S. Fish and Wildlife Service; to ensure that management actions will in no way affect nesting eagles. The Bald Eagle Recovery Plan identifies measures which will be incorporated into project plans and implemented during treatment.

The impact of *B.t.* on spotted owls is not expected to be substantial. Disturbance during aerial application has the greatest potential for negative impact on nesting, brooding or juvenile spotted owl.

A list of candidate species, which may be found in some areas, was provided by the U.S. Fish and Wildlife Service. No substantial effect from treatment would be anticipated for these species.

Threatened and endangered or candidate plants, which are located in some of the analysis units, could be affected to some degree by application of *B.t.* formulations considered in this analysis.

Dipel 4L and Dipel 8L were applied to foliage in the Seattle, Washington, area in 1983 and 1984, respectively. Some "burning" of new foliage on tender-leaved ornamentals and hardwood species such as linden and vine maple, was noted. Effects were limited to the leaf area where a spray droplet actually landed, and seemed to be mechanical damage rather than chemical toxicity. The spraying was done on sunny days; and on-the-ground personnel suspect the mineral oil carrier tended to focus light on spray contact points and burn the foliage beneath the droplets.

Macfarlane's Four O'clock, a federally listed endangered species, is present within Region 6. Treatment could be expected to have no substantial effect on this species.

Annual plant species dependent upon insects for pollination would be adversely affected if pollinating insect populations were eliminated. However, no substantial reductions in these populations would be expected with *B.t.* treatments.

A historic record of identified populations of threatened, endangered, and sensitive plants located on National Forest lands are kept of file. To prevent misues, access to this information has been limited.

This information would be used and necessary mitigation/monitoring would be identified in the site specific analysis.

Alternative C

Under this Alternative (the use of carbarly only) the potential effects on threatened, endangered, and sensitive species are greater than those expected under the other action Alternatives. Carbaryl, and the diesel oil/kerosene carriers, present a greater potential impact to non-target species than *B.t.* However, negative impacts on these species are not expected to be substantial. As with the application of *B.t.* (Alternative B), the most probable direct impact would result from the mechanical activities associated with aerial application of carbaryl. Refer to Tables IV-II, IV-III, IV-IV and Appendix F.

Alternative D and E

The effect on threatened, endangered, and sensitive species would be similar to that described for *B.t.* Potential for direct impact would be greatest from mechanical activities associated with the aerial application of insecticide.

Mitigating Measures

Section 7 of the Endangered Species Act directs the Forest Servie, as a Federal agency, to ensure that actions authorized, funded or carried out by them are not likely to jeopardize the continued existence of any threatened or endangered species or which may result in the destruction or adverse modification of critical habitats.

To ensure that proposed activities will not jeopardize the continued survival of any threatened, endangered or sensitive species, Forest Service activities which might disturb these species or their habitat must be preceded by a biological evaluation (FSM 2670). The Forest Service will initiate consultation or conference with the U.S. Fish and Wildlife Service when there is a determination that proposed activities may have an adverse effect on threatened, endangered or proposed species. Mitigating measures for threatened or endangered species, developed in coordination with the U.S. Fish and Wildlife Service, would be incorporated into the project operations plan to ensure that treatment and related activities would have no effect. All Forest Service projects will comply with appropriate recovery plans for threatened and endangered species.

In areas planned for treatment, the project leader would coordinate with the Forest Threatened, Endangered, and Sensitive Species Coordinator, and take appropriate action to ensure that threatened, endangered, or sensitive species are protected.

Fisheries/Aquatic Ecosystem

Alternative A - No Action

Most data indicate that even with heavy infestations of spruce budworm, most tree defoliation would be less than 100 percent, while stem mortality over the outbreak area would be less than 3 percent. Given these values, it is unlikely that water temperatures of streams in affected areas will be significantly altered. Therefore, no effects on fisheries resulting from water temperature increases are expected. Low levels of tree mortality in riparian areas have the potential to add organic debris to streams and, thereby, enhance fisheries habitat. Sedell and Luchessa (1981) pointed out the importance of organic debris in streams in relation to fisheries habitat.

Budworm larvae falling into streams or wetlands in areas of heavy infestation could enhance food supplies and beneficially affect fish growth rates.

The No-action Alternative, having minimal adverse impacts on water quality, would have similar minimal effects on fisheries. Minor amounts of streamside shade could be lost. Tree mortality occurring on stream sides would add woody debris to fish habitat, providing cover and pools. Fish populations would benefit from such habitat improvement. Aquatic invertebrates would not be affected by the No-action Alternative. This alternative would have the least impact or risk of impact upon aquatic invertebrates and fish.

Alternative B

Few toxic effects have been reported in studies of aquatic species exposed to *B.t.* While monitoring aquatic species on Moresby Island, British Columbia, in 1960, Todd and Jackson (1961) found no adverse effects on coho salmon fry, or on aquatic insects in streams within an experimental area treated with *B.t.* In studies in Algonquin Park, Ontario, Canada, fish and bottom fauna suffered no adverse effects up to 4 weeks after spraying (Buckner et al., 1974). Ignoffo (1973) found *B.t.* to be toxic to coho salmon only at high concentrations found following a direct spill into a stream.

Several acute toxicity tests conducted on fish are reported by Fisher and Rosner (1959). A 4-day toxicity study was conducted with *B.t.* on rainbow trout and bluegills in which two groups of ten fish each were placed in water containing *B.t.* at

concentrations of 560,000 and 1,000,000 ppb. None of the trout or bluegills died (Fisher and Rosner, 1959). Rainbow trout that were 4 inches long were exposed to *B.t.* at concentrations of 100,000 to 1,000,000 ppb for 14 days. No deaths resulted, nor were symptoms of alimentary or behavioral disturbances evident (Fisher and Rosner, 1959). In a test with juvenile coho salmon (1.6 inches long), *B.t.* was shown to be about 1/30 as toxic as DDT. The test ran for 168 hours with concentrations of 8,000 to 406,000 ppb. The 48-hour median tolerance limit of *B.t.* was about 50,000 ppb (Fisher and Rosner, 1959). In other words, for 48 hours, 50 percent of the fish tested tolerated a *B.t.* concentration of 50,000 ppb with no observable adverse effects.

Other toxicity test results are listed in the chemical profile for *B.t.* contained in the Environmental Assessment Western Spruce Budworm Management in Northeastern Oregon, Appendix 1984 (1984 EA). A summary of these data indicates no reason to suspect impacts upon aquatic fauna other than aquatic lepidopterans and selected dipterans (flies). Aquatic moth species belonging to the family Pyralidae are not known to occur within the area. In a study by Eidt (1985), blackfly larvae (Simuliidae), demonstrated susceptibility to *Bacillus thuringiensis* var. *kurstaki (B.t.k.)* in concentrations of 430 International Units/liter. *B.t.k.* has also been tested and found to be more or less toxic to several species of mosquitos (Krieg and Langenbruch, 1981). Two crustacean species in the genera *Daphnia* and *Cyclops*, and a mayfly species, *Picromerus bidens*, were tested in Eidt's study and shown to suffer no effects from *B.t.k.* Other varieties of *B.t.* have also demonstrated toxicity to some species of mosquitos and blackflies. *Bacillus thuringiensis* var. *kurstaki* is the variety being considered in this analysis.

Unlike chemical insecticide testing which often produces widely varying results, the testing of *B.t.* has proven to be more consistent in its effects upon nontarget organisms. As a result, *B.t.* is used in the East without extensive monitoring programs. The study by Eidt (1985) demonstrating no toxicity to mayfly, stonefly, and caddisfly larvae, and toxicity only in high concentrations (430 International Units/liter) to blackfly larvae, has resulted in a policy change. New Brunswick regulations no longer require stream and lakeside buffers when using *B.t.* field applications where worst-case scenarios project concentrations of less than 4.3 International Units/liter. Therefore, the concentration of 430 International Units/liter represents a value 100 times greater than that which would be expected in a direct application to water.

B.t. treatments in streamsides would pose no threat to aquatic organisms unless a direct spill occurred. Concentrations in streams resulting from normal treatment would be far below the levels that proved toxic to blackfly and mosquito larvae. The adverse effects of spills would be short-term and limited to relatively small stream reaches.

Table IV-V

Representative Aquatic Species Used in the Analysis

Common Name	Scientific Name
Rainbow trout	*Salmo gairdnerii*
Brook trout	*Salveliuus fontinalis*
Cutthroat trout	*Salmo clarki*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomieui*
Bluegill	*Lepomis macrochirus*
Yellow perch	*Perca flavescens*
Water flea	*Daphia* sp.
Stonefly	*Plecoptera* sp.
Scud	*Gammarus* sp.

The risk of spills, and subsequent contamination of water with fuel and/or large quantities of *B.t.*, is very low.

Alternative C

Carbaryl

In most cases, carbaryl poses low risk to fish in ponds or streams when a 500 foot buffer strip is maintained. If the body of water is very shallow (6 inches or less in depth), there may be moderate risks to some trout species. Aquatic invertebrates, such as water fleas, stoneflies, and scuds, are at significant risk if the estimated environmental concentrations calculated in this analysis are present for anything but a transient time period, as would be the case in shallow ponds or very slow-moving streams.

Diesel Oil and Kerosene

Petroleum distillates would pose significant risks to all representative aquatic species if the concentrations calculated in this risk assessment were not transient.

Alternative D

The impact on fisheries and aquatic systems is expected to be somewhat less than effects from Alternative C.

Alternative E

The impacts on fisheries and aquatic systems is expected to be similar to Alternative B in most cases. If carbaryl is used, the impacts expected to the aquatic system would be somewhat less than expected for Alternative D.

Mitigating Measures

Aerial insecticide application near streams and open water is controlled by State law. In Oregon, State regulatory agencies have agreed that *B.t.* may be aerially applied parallel to and up to the edges of streams and open water. A variance must be obtained from the Washington State Department of Ecology to apply *B.t* up to the edges of streams in that State.

A buffer zone will be left adjacent to streams, lakes, wetlands, and other waterways when applying carbaryl. This buffer strip must be at least one swath wide.

The following measures will be used to minimize the probability of unintentional adverse affects on water-related resources and nontarget organisms from spills or application errors:

- Aircraft spray equipment calibration testing over wetlands or floodplains will be prohibited.
- A pilot car will be required during transportation of insecticides or fuel on roads within municipal watersheds.
- Helispots will not be located in or adjacent to meadowlands or floodplains.
- Wetlands, including lakes and ponds, which are large enough to identify from the air, will not be oversprayed with insecticides. There may be relatively small wet areas that, because of the tree canopy cover, cannot be identified from the air which will be unavoidably but inadvertently sprayed.

Aquatic Species Risk Assessment

Risks to aquatic species were calculated using the same basic risk assessment process that was used to calculate risks to terrestrial wildlife. Details can be found in Appendix F. Table IV-V lists the representative aquatic species.

Hazard Analysis

Carbaryl

Carbaryl degrades rapidly in surface waters, in 1 to 5 days. It is not subject to significant bioaccumulation in aquatic ecosystems because of its low solubility and low octanol-water partition coefficient (Kow=230). Uptake in fish has been detected, with 95 percent excreted within 8 hours.

LC_{50}'s of carbaryl for representative aquatic species are presented in Tables IV-VI through IV-IX. Catfish and minnows are nearly ten times more tolerant of carbaryl than trout. The toxicity to sunfish and bass is approximately midway in this range. Cholinesterase depression has been observed in brook trout and Atlantic salmon when bodies of water were sprayed at 1 lb a.i./acre.

Aquatic invertebrates are highly sensitive to low levels of carbaryl. Populations may be significantly reduced in streams or ponds that are directly sprayed or receive a large amount of spray drift.

Carbaryl has been demonstrated to increase the growth rate of algae, possibly due to an increase in the nutrient nitrogen resulting from carbaryl degradation.

Diesel Oil and Kerosene

Petroleum distillates are moderately to highly toxic to fish and invertebrate aquatic species. The LC_{50} for water fleas is 210 MG/L.

Exposure Analysis

Exposures to aquatic species are based on estimated environmental concentrations (EEC's) in water. EEC's were calculated for typical and worst case

scenarios for bodies of water with depths of 2 inches, 6 inches, 1 foot, and 2 feet. Typical exposures assume a buffer zone of 500 feet, and worst-case exposures assume a buffer zone of 100 feet. EEC's were also calculated for an accidental direct spray of a 2 foot deep body of water and for a 200 gallon spill of carbaryl mixture into a 2 foot deep, 1 acre pond.

Risk Analysis

The risk analysis compared the EEC's to the LC_{50}'s by computing a Q-value, equal to the EEC divided by the LC_{50}. If the Q-value is less than 0.1, there is assumed to be a low or negligible acute risk to aquatic species. If it is between 0.1 and 0.5, there is a presumption of a moderate risk that may be mitigated by appropriate measures. If the Q-value exceeds 0.5, there is a significant, unacceptable risk to aquatic species.

Results of the risk analysis for aquatic species are presented in Tables IV-VI through IV-IX.

Table IV-VI

Acute Risk* from Carbaryl in Routine Operations to Aquatic Species in Varying Water Depths

Representative Species	LC_{50} or EC_{50} (PPB)	Q-Value (EEC/LC_{50})			
		Depth = 2 in.	Depth = 6 in.	Depth = 1 ft.	Depth = 2 ft.
	Typical EEC =	420 PPB	140 PPB	70 PPB	35 PPB
Rainbow trout	1950	0.22*	0.072	0.036	0.018
Brook trout	1100	0.38*	0.13*	0.064	0.032
Cutthroat trout	1500	0.28*	0.093	0.047	0.023
Largemouth bass	6400	0.066	0.022	0.011	0.0054
Smallmouth bass	6400	0.066	0.022	0.011	0.0054
Bluegill	39000	0.011	0.036	0.0018	0.00090
Yellow perch	5100	0.082	0.028	0.014	0.0068
Water flea	6.4	65**	22**	11**	5.4**
Stonefly	1.7	250**	82**	42**	20**
Scud	22	19**	6.4**	3.2**	1.6**
	Worse Case EEC =	1300 PPB	430 PPB	220 PPB	110 PPB
Rainbow trout	1950	0.67**	0.22*	0.11*	0.055
Brook trout	1100	1.2**	0.40*	0.20*	0.098
Cutthroat trout	1500	0.87**	0.29*	0.14*	0.072
Largemouth bass	6400	0.20*	0.068	0.034	0.017
Smallmouth bass	6400	0.20*	0.068	0.034	0.017
Bluegill	39000	0.033	0.011	0.0056	0.0028
Yellow perch	5100	0.26*	0.085	0.042	0.021
Water flea	6.4	200**	68**	34**	17**
Stonefly	1.7	760**	260**	130**	64**
Scud	22	59**	20**	9.9**	4.9**

* = Moderate Risk
** = Significant Risk

Table IV-VII

Acute Risk* from Petroleum Distillates in Routine Operations to Aquatic Species in Varying Water Depths

Representative Species	LC_{50} or EC_{50} (PPB)	Q-Value (EEC/LC_{50})			
		Depth = 2 in.	Depth = 6 in.	Depth = 1 ft.	Depth = 2 ft.
	Typical EEC =	460 PPB	150 PPB	76 PPB	38 PPB
Rainbow trout	190	2.4**	0.80**	0.40*	0.20*
Brook trout	190	2.4**	0.80**	0.40*	0.20*
Cutthroat trout	190	2.4**	0.80**	0.40*	0.20*
Largemouth bass	190	2.4**	0.80**	0.40*	0.20*
Smallmouth bass	190	2.4**	0.80**	0.40*	0.20*
Bluegill	190	2.4**	0.80**	0.40*	0.20*
Yellow perch	190	2.4**	0.80**	0.40*	0.20*
Water flea	210	2.2**	0.72**	0.36*	0.18*
Stonefly	---	---	---	---	---
Scud	---	---	---	---	---
	Worse Case EEC =	2800 PPB	950 PPB	480 PPB	240 PPB
Rainbow trout	190	15**	5.0**	2.5**	1.2**
Brook trout	190	15**	5.0**	2.5**	1.2**
Cutthroat trout	190	15**	5.0**	2.5**	1.2**
Largemouth bass	190	15**	5.0**	2.5**	1.2**
Smallmouth bass	190	15**	5.0**	2.5**	1.2**
Bluegill	190	15**	5.0**	2.5**	1.2**
Yellow perch	190	15**	5.0**	2.5**	1.2**
Water flea	210	14**	4.5**	2.3**	1.1*
Stonefly	---	---	---	---	---
Scud	---	---	---	---	---

* = Moderate Risk
** = Significant Risk

Table IV-VIII

Acute Toxicity Risk Analysis for Carbaryl for Accidents

Representative Species	LC_{50} or EC_{50} (PPB)	Q-Value (EEC/LC_{50})	Risk Level
200 GALLON SPILL INTO POND, EEC = 7,350 PPB			
Rainbow trout	1950	3.78E+01	Significant
Brook trout	1100	6.70E+01	Significant
Cutthroat trout	1500	4.91E+01	Significant
Largemouth bass	6400	1.15E+01	Significant
Smallmouth bass	6400	1.15E+01	Significant
Bluegill	39000	1.8885	Significant
Yellow perch	5100	1.44E+01	Significant
Water flea	6.4	1.15E+04	Significant
Stonefly	1.7	4.33E+04	Significant
Scud	22	3.35E+03	Significant
DIRECT SPRAYING OF WATER BODY AT MAX. RATE, EEC = 184 PPB			
Rainbow trout	1950	0.0944	Low
Brook trout	1100	0.1673	Moderate
Cutthroat trout	1500	0.1227	Moderate
Largemouth bass	6400	0.0288	Low
Smallmouth bass	6400	0.0288	Low
Bluegill	39000	0.0047	Low
Yellow perch	5100	0.0361	Low
Water flea	6.4	2.88E+01	Significant
Stonefly	1.7	1.08E+02	Significant
Scud	22	8.3636	Significant

Table IV-IX

Acute Toxicity from Petroleum Distillates to Aquatic Species from Accidents

Representative Species	LC_{50} or EC_{50} (PPM)	Q-Value (EEC/LC_{50})	Risk Level (Based on EPA, 1986)
200 GALLON SPILL INTO POND, EEC = 161 PPM			
Rainbow trout	.19	850	Significant
Brook trout	.19	850	Significant
Cutthroat trout	.19	850	Significant
Largemouth bass	.19	850	Significant
Smallmouth bass	.19	850	Significant
Bluegill	.19	850	Significant
Yellow perch	.19	850	Significant
Water flea	.21	770	Significant
Stonefly	---	---	No data
Scud	---	---	No data
DIRECT SPRAYING OF WATER BODY AT MAX. RATE, EEC = 0.403 PPM			
Rainbow trout	.19	2.1	Significant
Brook trout	.19	2.1	Significant
Cutthroat trout	.19	2.1	Significant
Largemouth bass	.19	2.1	Significant
Smallmouth bass	.19	2.1	Significant
Bluegill	.19	2.1	Significant
Yellow perch	.19	2.1	Significant
Water flea	.21	1.9	Significant
Stonefly	---	---	No data
Scud	---	---	No data

Visual Resources

The American people are concerned about the visual quality of their environment. The "visual landscape" is a basic resource, to be "treated as an essential part of and receive equal consideration with the other basic resources of the land".

The majority of the recreation-oriented people who visit the National Forests have an image of what they expect to see. Such an image or mental picture is generated by available information concerning a particular area and the person's experience with that or similar areas. The image produced represents the perceptions, expectations, romanticism, and emotionalism associated with features within the area. Obviously, several images may exist simultaneously, even within a single individual, and yet a particular geographic region tends to have an identifiable image.

Although studies of people's images of forest areas result in varied responses from one geographic region to another, one factor generally remains constant. People expect to see a naturally appearing character within each general region.

Aesthetic concern varies among National Forest users. Those people most concerned about aesthetics are those who are in an area because of, or have a major interest in the scenic qualities, e.g., recreationists, residents, and travelers.

The visual impact of spruce budworm defoliation increases as the duration of view increases beyond a quick glance. Examples are those areas seen from vista points, visitor centers, and scenic highways. The visual impact of spruce budworm defoliation becomes more important as the actual or potential number of viewers increase.

Each landscape has a definable character, and those with the greatest variety or diversity have the greatest potential for high scenic value.

Landscapes vary in form, line, color, and/or texture. Spruce budworm defoliation has the greatest impact on color and texture. Each landscape unit has its individual capacity to accept alterations in color and texture without losing its inherent visual character. The visual impact of defoliation increases as the amount of landscape color and texture alteration increases.

Visibility and clarity of detail are often functions of viewing distance. The visual impact of defoliation usually increases as viewing distance decreases. Distance zones are divisions of a particular landscape being viewed and are used to describe parts of a characteristic landscape. The three distance zones are:

Foreground

The limit of this zone is based on distances at which details can be perceived. Normally, in foreground views the individual boughs of trees form texture. Foreground will usually be limited to areas within one-fourth to one-half mile of the observer.

Middleground

This zone extends from the foreground zone to 3 to 5 miles from the observer. Texture normally is characterized by the masses of trees in stands of uniform cover. Individual tree forms are usually only discernible in very open or sparse stands.

Background

This zone extends from middleground to infinity. Texture in stands of uniform tree cover is generally very weak or nonexistent. In very open or sparse timber stands, texture is seen as groups or patterns of trees.

Sensitivity Level

Sensitivity levels are a measure of people's concern for the scenic quality of the National Forests.

Sensitivity levels for land areas viewed are determined by those who travel through the Forest on developed roads and trails, those who use areas such as campgrounds and visitor centers, or those who take their recreation at lakes, streams, and other bodies of water. Three sensitivity levels are defined, each identifying a different level of user concern for the visual environment:

Level 1 - Highest Sensitivity

Level 2 - Average Sensitivity

Level 3 - Lowest Sensitivity

Sensitivity Level 1 includes all areas seen from primary travel routes, use areas, and bodies of water where, as a minimum, at least one-fourth of the Forest visitors have a major concern for the scenic qualities. Examples are all areas seen from primary roads, primary trails used by hikers and horsemen, and primary use sites within National Parks, National Recreation Areas, Wilderness Areas, and other dedicated Wild Areas.

Sensitivity Level 1 also includes all areas seen from secondary travel routes, use areas, and bodies of water where at least three-fourths of the Forest visitors have a major concern for the scenic qualities.

Sensitivity Level 2 includes all areas seen from primary travel routes, use areas, and bodies of water where fewer than one-fourth of the Forest visitors have a major concern for scenic qualities.

Level 2 also includes all areas seen from secondary travel routes, use areas, and bodies of water where at least one-fourth, and not more than three-fourths, of the Forest visitors have a major concern for scenic qualities.

Level 3 includes all areas seen from secondary travel routes, use areas, and bodies of water where less than one-fourth of the Forest visitors have a major concern for scenic qualities. (Level 3 does not include any areas seen from primary routes or areas.)

Alternative A - No Action

The impact of continued defoliation on visual quality and the Forest users' experience will be greatest in the areas where severe defoliation is found. These areas will display extreme color and texture changes for up to a decade or more. The most sensitive of these areas will be the foreground zones that are seen by the greatest number of visitors. This drastic change in color and texture persists over several years.

The most severe cases of defoliation result in top-kill and mortality and may reduce the value of the landscape to Forest users. Recreation use could decline as a result of continued defoliation, with a corresponding impact on the recreation economy.

In low elevation areas, the long-term effect of severe defoliation could result in the creation of a more diverse forest, with tree species resistant to spruce budworm attack. This would result in a landscape less susceptible to change in color and texture from spruce budworm infestations. This process of long-term change in tree species would take several decades.

The cumulative effect of the No Action Alternative would be an increase in the acres of defoliation and visual change that occur each year; changes which would continue until budworm populations are reduced by natural events.

There are potential conflicts between this Alternative and other plans and policies for management of the visual resource. Conflicts result when landscape quality management objectives cannot be met due to the impact of severe defoliation.

Alternatives B, C, D and E

Short-term protection of foliage by using *B.t.* or carbaryl reduces the changes in color and texture that occur on the landscape, but does not eliminate them. Color and texture changes are still detectable. Protection of foliage reduces cumulative mortality and top-kill. The landscape will maintain a more natural-appearing character. Low levels of spruce budworm defoliation will make slightly visible impacts on color and texture. Only slight reductions in recreation user numbers would be expected when foliage protection is provided at intervals sufficient to maintain the natural appearance. The economic impacts should be low. Specific distance zones and sensitivity areas can be selectively protected from severe defoliation.

The long-term effect of protecting foliage would be the maintenance of a forest composed of tree species which are susceptible to continued defoliation. This would result in a landscape which is more susceptible to changes in color and texture.

Public notification of pending suppression projects might result in short-term loss of recreational opportunities for those who elect to not visit the project vicinity.

The cumulative effect of implementing Alternatives B, C, D or E would be an annual reduction in acres severely defoliated.

There are no conflicts expected between these Alternatives and other plans and policies for management of the visual and recreation resource.

Mitigating Measures

The action Alternatives would mitigate additional loss of visual quality caused by the western spruce budworm epidemic.

Cultural Resources

Alternative A - No Action

Under this Alternative, there would be no change from the effects expected in ongoing Forest management operations.

Alternatives B, C, D and E

The only ground-disturbing activity which would result from implementation of any of these Alternatives would be some limited clearing for and construction of heliport sites within forested areas.

Mitigating Measures

Before any ground-disturbing activities occur, previously undisturbed and unsurveyed areas would be examined by qualified personnel for the presence of cultural resources. Appropriate measures would be taken to protect cultural resource sites discovered, to ensure that cultural information is not lost. The State Historical Preservation Officers in Oregon and Washington would be consulted on each proposed site.

Wilderness

The Forest Service Manual defines several objectives in regard to management of insects and plant disease in Wilderness Areas (FSM 2324.1):

1. "To allow indigenous insect and plant diseases to play, as nearly as possible, their natural ecological role within wilderness.

2. To protect the scientific value of observing the effect of insects and diseases on ecosystems, and to identify genetically resistant plant species.

3. To control insect and plant disease epidemics that threaten adjacent lands or resources."

Studies of the life cycle of the western spruce budworm suggest that a no-treatment policy in Wilderness Areas does not pose a threat to adjacent lands or resources within Wilderness boundaries. Therefore, in most instances natural processes would continue without direct human interference.

In situations where spruce budworm infestations in Wilderness Areas are thought to have a potential to affect adjacent resources, the need for treatment would be evaluated on a case-by-case basis.

Population levels would be monitored "in a manner that preserves the Wilderness character of the area."

If insecticide treatment is determined to be necessary in specific cases, to prevent unacceptable damage to lands adjacent to Wilderness Areas, treatment measures must have a minimum impact on the Wilderness resource and be compatible with Wilderness management objectives.

Alternative A - No Action

Since the western spruce budworm is an indigenous component of the forest environment, any effects on forested areas during a naturally occurring budworm outbreak are, by policy, an acceptable part of the natural ecology.

Alternatives B, C, D and E

Many people would be concerned about the use of any insecticide within National Forest Wilderness Areas, since application of insecticides is not a naturally occurring event. Insecticide application would interfere with natural processes which are essential to the Wilderness resource. Also, the application process would detract from the solitude and primitive recreation experience offered in Wilderness Areas.

Recreation/Public Use

National Forests in the Pacific Northwest provide recreational opportunities for millions of people every year. People seek enjoyment in National Forests. Opportunities for recreation are as diverse as the land itself. Recreation experiences vary from physical challenges and solitude in pristine Wildernesses, to social gatherings in camp and picnic facilities.

Traditional uses such as camping, picnicking, hunting, fishing, and hiking, take place on all National Forests. Many activities have been popular as long as public lands have been available for those uses. The recent popularity of other recreation pursuits, such as cross-country skiing, wind surfing, and bicycle touring, have created new opportunities for people to enjoy National Forests. As the availability of leisure time increases and the pressures of urban life become more intense, the need to enjoy the natural environment which National Forests provide becomes significantly more important.

We allow ourselves recreation when we are free from other demands on our time. Outdoor recreation in a natural environment provides many social and psychological benefits; physical exercise, mental stimulation, relaxation, and enjoyment, to name a few. Nature also provides a sense of stability, internal harmony, and balance; according to laws not subject to human manipulation. National Forests offer an opportunity to escape from urban life and social pressures, find order and purpose in our lives, review our sense of values, and strengthen family ties.

Visual quality in recreational areas may be directly and adversely affected by a western spruce budworm infestation. When tree damage becomes significant, particularly in recreation areas and travel corridors, the quality of the recreational experience may be especially affected. Short-term effects of budworm damage are most apparent in the browning of tree foliage. Long-term, cumulative effects are spike tops (dead tops) in pole sized timber and mature trees, and substantial tree mortality. Some recreation areas in host-type stands of timber may become less desirable when the perceived quality of the recreation experience is affected by defoliation. The enjoyment of some Forest visitors may depreciate from this loss in scenic quality.

Human Health

A risk assessment was done to assess the risks to human health of using the chemical insecticide, carbaryl and the biological control agent, *Bacillus thuringiensis (B.t.)* for controlling western spruce budworm in Region 6. That risk assessment is Appendix F of this EIS. The risk assessment also assessed the human health risks of malathion and acephate; however, those two insecticides are not discussed here because they were eliminated from detailed consideration as spruce budworm insecticides.

The risk assessment also addressed the human health risks of a number of chemicals associated with the application of the insecticides and *B.t.* Because carbaryl is commercially formulated (as Sevin 4-Oil) with kerosene, and because diesel oil is used as a carrier in the application of Sevin 4-Oil, the risks of these two petroleum distillates were analyzed. The risks were evaluated for the two products separately and combined because of their similarity and use in the same mixture. (Petroleum distillates are listed by EPA as potentially toxic inert ingredients with a high priority for testing.) The risk assessment also looked at mineral oil, a *B.t.* formulation ingredient; N-nitrosocarbaryl, a carcinogenic metabolic product of carbaryl that may form in the stomach after oral exposures; malaoxon, a metabolic product of malathion; and methamidophos, a toxic degradation product of acephate. The latter two chemicals are not discussed here because malathion and acephate were eliminated from detailed consideration.

The risk assessment examined the potential health effects to all persons who might be exposed to the insecticides and associated chemicals as a result of activities related to spruce budworm spray programs. The two groups of people considered at risk were worker personnel directly involved in application of the insecticides and the public. The public included forest visitors and residents who could be exposed to drifting insecticide spray droplets getting on their skin by touching sprayed vegetation, or by consuming contaminated food items or water.

The analysis used the methodology of risk assessment generally accepted by the scientific community. In essence, the risk assessment estimated doses people may get from applying the insecticides (worker doses) or from being near an application site (public doses), then compared those estimated doses with doses shown to cause no observed effects in tests on laboratory animals.

Human Health Risk Assessment

The risk assessment employed three principal analytical elements: hazard analysis, exposure analysis, and risk analysis. The relationship among these components is illustrated in Figure IV-I.

Hazard Analysis

The hazard analysis identified the toxic properties of *B.t.*, and of each chemical insecticide originally considered for the program, in a thorough review of available toxicological studies. Scientific uncertainty about the results of these studies was considered in determining their usefulness in characterizing the toxicity of the material in question. When no studies were identified for a particular toxicity endpoint, for example, mutagenicity, these data gaps were identified and a worst-case analysis was conducted for this endpoint. The hazard analysis is presented in Appendix F.

Exposure Analysis

The risk assessment analyzed a range of possible exposures--from realistic to extreme--using three types of scenarios:

1. Typical application scenarios (routine-typical) to estimate worker and public doses that may reasonably be expected to occur during routine operations.

2. Worst-case application scenarios (routine worst-case) to give very high dose estimates not likely to be exceeded except in the case of an accident.

3. Accident scenarios to estimate public and worker doses from exposure to spray mix or concentrate, directly or in spills into drinking water.

To establish the most appropriate scenarios, the exposure analysis considered the characteristics of the spraying operations (including application methods, application rates, size and configuration of spray areas, project design features, and mitigation measures), the human populations likely to be exposed, and the routes of exposure for humans in routine operations and as a result of accidents.

The insecticides examined in the risk assessment are applied aerially, using fixed-wing or helicopter aircraft, or by backpack sprayer for seed orchards or campgrounds. The size of the program may vary in any given year. A total of 25,000 acres may be sprayed in 1 day, but no more than 5,000 acres in a single watershed. The risk assessment (Appendix F) contains further details about spray operations.

For members of the public, including forest visitors and nearby residents, the routine typical and routine worst-case exposure scenarios estimated doses from

Figure IV-I

Components of the Risk Assessment Process

Hazard Analysis	Exposure Analysis
Identify what kinds of health effects have been observed in laboratory studies, including animal models, and at what levels of exposure	Identify types of people exposed
Identify any health effects that have been observed in humans	Identify expected routes of exposure
Determine median lethal dose (LD_{50}) for acute effects from laboratory rat study	Estimate the exposure each person would receive by each route, using both routine and extreme case scenarios
Determine lowest no-observed-effect levels (NOEL's), if possible, for general chronic toxic effects, reproductive effects, and birth defects	Estimate frequency and duration of exposure
Determine whether the pesticide has carcinogenic or mutagenic potential	Calculate doses
Identify data gaps in toxicity information	

Risk Analysis
Compare doses to NOEL's and LD_{50}'s and discuss probability of acute and chronic effects (including birth defects) for routine through worst-case scenarios
Conduct extreme case analysis for cancer risk

the three principal routes. Oral doses were assumed to come from eating meat, fish, berries, garden vegetables, or drinking water with insecticide residues. Dermal doses came from vegetation contact and drift exposure, and inhalation doses from drift exposure. Cumulative exposures to hypothetical hunters and fishermen from several exposure routes also were calculated. Worker exposures were estimated for pilots, mixer/loaders, aerial and ground-based observers, card checkers, and efficacy evaluation team members. Cumulative lifetime doses were estimated for the analysis of lifetime cancer risk by using information on average and maximum treatment days per year and on average and maximum number of years exposed for workers and for the public.

A number of accident scenarios also were analyzed including direct aerial application of insecticide on a person, spills of concentrate or insecticide mix on workers during mixing and loading, spills of insecticide into drinking water supplies, and direct spraying of garden vegetables.

Two special case analyses were done to evaluate the risk from hypothetical circumstances of exposure thought possible in spraying of a forested watershed for budworm suppression. The first special case involved estimating exposures for persons drinking water from reservoir feeder streams and from a reservoir itself immediately after rainfall runoff contaminates the streams and reservoir. The runoff in each feeder stream is assumed to come from one of three 5,000-acre spray blocks on The Dalles watershed which are sprayed in sequence on 3 consecutive days. A rainstorm follows on the fourth day. The second special case analysis involved estimating exposure from consuming crops that have been irrigated with contaminated reservoir water.

Risk Analysis

The risk of acute and chronic health effects was evaluated by comparing estimated doses to no-observed-effect-levels (NOEL's) in laboratory animal studies, using a margin of safety (MOS). The MOS is calculated by dividing the NOEL by the estimated dose. A benchmark risk MOS of 100 was used to assess the likelihood of effects. Doses that are 100 times lower than the laboratory NOEL are assumed to present a low risk of human health effects. Risk increases as the estimated dose approaches the laboratory toxicity level; that is, as the MOS decreases.

The risk of cancer at a given level of exposure, based upon the estimated average daily exposure over a 70-year lifetime, was derived for each insecticide from a cancer potency value based upon laboratory animal data on tumor incidence at increasing dose levels.

The risk of cancer was calculated for an estimated lifetime dose for various categories of people who may be exposed to insecticides through various routes.

The risk of heritable mutation was evaluated based upon the weight of evidence from available test data on bacteria, yeasts, plants, mammalian cells in culture, and whole animals. When no test data were available for an insecticide, a worst-case assumption was made that the insecticide is mutagenic, and that risk is then based upon the insecticide's estimated cancer risk. This approach, discussed in detail in the risk assessment, assumes that genotoxic agents would be detected as carcinogens from lower exposures than would be required to induce heritable damage in germ cells.

Risk to more highly sensitive individuals, such as the aged or children who may be affected at extremely low exposure levels, was based on the likelihood of a sensitive individual being exposed.

Risks to human health from the use of *Bacillus thuringiensis* were evaluated based upon the available evidence of toxicity of this biological insecticide in studies of exposed humans and laboratory animals. An MOS value is calculated for inhalation and oral *B.t.* exposures. However, these MOS's may not be appropriate in the case of *B.t.* since much of the rationale involving MOS is derived from known genetic differences in chemical metabolism, DNA repair, detoxification of molecules, and excretion of metabolites, none of which applies to *B.t.* *B.t.* effects on reproduction are not known, so no MOS for those effects could be calculated. In addition, the *B.t.* analysis does not take into account infectivity; that is, illness caused by the vegetative stage of the *Bacillus* life cycle.

Data Gaps and Uncertainties

There were a number of data gaps and areas of uncertainty identified in the risk assessment. In each of those areas, a conservative approach was used or a worst-case analysis was done that tended to increase the estimates of risk to err on the side of safety.

The information data gaps include:

1. Field studies on exposure to workers.

2. Information on public exposure.

3. Field data on residue levels in plants and animals.

4. Mutagenicity study data for carbaryl (DNA damage.)

5. Toxicity information on the cumulative effects from exposure to forestry-use insecticides, other pesticides, and/or other chemicals.

6. Toxicity, infectivity, and exposure information for *B.t.* (var. kurstaki) to supplement the data from the history of its use.

These information gaps are important in deciding the best alternative for action; however, the cost of obtaining this information is an important consideration.

The overall costs for conducting studies to fill the data gaps is considered exorbitant for the limited funds available. In addition, the time necessary to perform and evaluate most of these tests is more than 2 years, and would seriously delay making decisions about managing western spruce budworm. Many of the desired toxicological studies have already been requested by EPA, and the results of these studies will be considered when they become available. In addition, ongoing research and monitoring programs to examine various aspects of insecticide treatment will continue, and these results will be considered as they become available.

Because the cost of filling the data gaps is considered exorbitant, a worst-case analysis was conducted for those areas where information is unavailable, or where there is uncertainty. The worst-case scenarios involving routine insecticide application operations consist of combinations of parameters, including treatment unit size, duration of exposure, application rate, application equipment, and meteorological conditions, that give the highest reasonable exposure value. Extreme exposures due to accidents were also evaluated, including those that could result from direct spills of concentrate on workers' skin, the direct spraying of an individual, and contamination of a public drinking water supply by an insecticide spill.

The worst-case analysis for mutagenicity assumed the insecticide could cause heritable mutations. The risk of heritable mutations was assumed to be no greater than the risk of cancer.

The worst-case analysis for insecticides that had either positive cancer studies, or for which there is scientific uncertainty, assumed these chemicals could cause cancer. A conservative cancer potency value for a chemical was computed by using the highest rates of tumor formation found in the available animal studies. A conservative model for estimating human cancer rates from tumor rates in laboratory animals was also used.

EPA has identified the data gaps shown in Section 2, Table F2-11, of the risk assessment located in Appendix F, in accordance with the registration guidelines under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. Although there are data gaps or areas of uncertainty for some of the insecticides in this risk assessment, there is a large body of existing data useful for predicting the behavior and toxicity of these insecticides, including the following:

1. Worker exposure studies with EPN (ethyl p-nitrophenyl thionobenzene phosphate) insecticide.

2. Studies on drift of the insecticide trichlorfon.

3. Residue information for the insecticides in plant and animal tissues.

A number of approaches were used to deal with uncertainties in data or methods used to evaluate risks. First, in evaluating risks to human health based upon laboratory animal studies, a benchmark level of 100 was established to allow for uncertainty in extrapolating from the no-observed-effect levels (NOEL's) in laboratory animals to levels deemed acceptable for humans. The generally accepted uncertainty factors (NRC, 1986) for establishing the benchmark were 10 for moving from animals to humans (interspecies variation) and another 10 to account for possible variation in human responses (intraspecies variation). This 10 times 10, or hundredfold, uncertainty benchmark means the laboratory NOEL dose reduced 1 hundredfold would normally be considered an acceptable dose for chronic exposure. In this risk assessment, a margin of safety (MOS) or "hazard level to exposure level" ratio was calculated for each estimated dose by dividing the animal NOEL by the estimated dose. The computed MOS was then compared to the benchmark level of 100 to evaluate the risks of toxic effects.

Second, the analysis compared doses that may occur perhaps a few times in a lifetime (accidental worker doses and all public doses) to dose levels of the chemical that produced no ill effects in laboratory animals exposed every day of their lives. This led to an exaggeration of the risks of these infrequent doses.

Third, to assess the risks of cancer (because they are assumed to pose some risk even at extremely low doses), a different approach was used. A cancer potency value (the probability of developing tumors at increasing dose levels) was taken from a laboratory animal study and multiplied by an estimated human lifetime dose to estimate human cancer risk. The analysis assumed some level of risk even at extremely low doses and the cancer potency was based on the highest level of tumor incidence in any animal study.

Finally, the methods of estimation of human doses likely to occur from insecticide use tended to overestimate doses to err on the side of safety. Workers are likely to be exposed routinely, but standard safety practices and protective clothing should reduce their actual dose levels below those

estimated in this analysis. No member of the public is likely to receive as high a dose as estimated in this risk assessment. Normal safety practice and the remoteness of most treated areas limit the possibility of the public's receiving any dose at all. In the estimates of public doses, no insecticide degradation on surfaces or in food and water was assumed to occur, and the public were not assumed to wash themselves or their food items after a spraying.

Risk Assessment Results

Hazard Analysis

This section summarizes the toxic properties of carbaryl, diesel oil, kerosene, and *Bacillus thuringiensis*. Complete toxicity discussions are given in Appendix F, Section 2. Table IV-X lists the toxicity reference values for the chemicals and *B.t.* used in the quantification of risk. Mineral oil, a formulation ingredient in *Bacillus thuringiensis,* is not an inert ingredient of concern and is not addressed here. The hazards associated with N-nitrosocarbaryl, a metabolic reaction product of carbaryl, are presented in this section.

The toxicity of carbaryl to laboratory animals, humans, wildlife, and aquatic species is described in detail in the background statements prepared for the Animal and Plant Health Inspection Service (APHIS) by Roy F. Weston, Inc. (Dobroski, 1985; Dobroski and Lambert, 1984; Lambert, 1985). Most toxicity data presented for *Bacillus thuringiensis* were obtained from a background statement prepared for the Forest Service by Mitre Corp. (Sassaman, 1987). Toxicological data for diesel oil and kerosene were obtained from a background statement prepared by Labat Anderson Incorporated.

Carbaryl

Acute, Subchronic, and Chronic Toxicity: Carbaryl has been tested in human volunteers at doses ranging from 0.06 mg/kg to 2.8 mg/kg. The highest dose caused epigastric pain and sweating. Depression in resorption of amino acids was seen at 0.13 mg/kg; no effects were seen at the 0.06 mg/kg dose. A human-reference dose of 0.1 mg/kg/day for chronic oral exposure was based on a 2-year rat study with a NOEL of 9.6 mg/kg/day. The systemic NOEL used in this risk assessment was 10 mg/kg/day (9.6 rounded off) based on the rat study. A systemic NOEL of 1.8 mg/kg/day, seen in a 1-year dog study, was not used for this analysis because of the differences in metabolism of carbaryl between dogs and humans. The carbaryl acute oral LD50 in rats is 270 mg/kg. This dose is used for evaluation of the effects of high accidental doses.

Reproductive/Developmental Toxicity: Carbaryl is teratogenic in many test species, with lowest NOELs found in dogs, but again, the dog effects are not assumed to extrapolate to humans. The

Table IV-X

Toxicity Reference Levels Used in the Analysis of Human Health Risks

Chemical	Rat Oral LD_{50} (mg/kg)	Systemic NOEL (mg/kg/day)	Reproduction/ Developmental NOEL (mg/kg/day)	Cancer Potency per (mg/kg/day)
Carbaryl	270	10.0	10.0	0.135*
Diesel Oil	7,380	7.38	751	0.0000049
Kerosene	28,000	28	751	0.0000049
Petrol. Distil.	7,380	7.38	751	0.0000049
Bacillus thuringiensis				
Inhalation	---	1.4	---	---
Oral	---	500	---	---

* Based on production of N-nitrosocarbaryl in the stomach after oral exposure.

reproductive/developmental NOEL used in this risk assessment was 10 mg/kg/day based on a study in rats.

Carcinogenicity: Despite speculation that carbaryl could combine with nitrite compounds to form a carcinogen (N-nitrosocarbaryl) under acidic conditions similar to those found in the human stomach, the majority of studies examining the carcinogenic potential of carbaryl have been negative. A preliminary report by the Carcinogen Assessment Group of EPA concluded there was no significant increase in the incidence of tumor induction among treated animals relative to control animals (EPA, 1988). The review of 10 chronic toxicity studies, and the absence of significant tumor incidence at 400 ppm in rats and mice, has provided sufficient evidence for EPA to conclude "that carbaryl is not oncogenic in experimental animals" (EPA, 1984).

N-nitrosocarbaryl has been characterized as a mutagen and a carcinogen based on positive laboratory studies (Eisenbrand et al., 1976; Elespuru and Lijinsky, 1973). Theoretically, it is possible that human exposure to N-nitrosocarbaryl could occur from the simultaneous dietary consumption of carbaryl (in food) and sodium nitrite (a food additive) even though the formation of N-nitrosocarbaryl under these conditions has not been documented (Cranmer, 1986). N-nitrosocarbaryl could cause cancer in the stomach or on the skin if it could form in the environment as a result of carbaryl application. However, literature shows that N-nitrosocarbaryl can form only under conditions similar to those found in the human stomach--not in the air or on the skin. Thus, cancer risk from N-nitrosocarbaryl was considered only for oral exposure in the risk assessment. Tumor results from chronic gavage studies with rats exposed to N-nitrosocarbaryl were used to calculate a cancer potency and to determine a potency for humans (Lijinsky and Taylor, 1976; and Lijinsky and Schmal, 1978, as cited in USDA, 1985). The cancer potency was 1.35 x 10-1 per mg/kg/day at the 95-percent upper confidence level. One percent of carbaryl was assumed to be converted in the stomach to N-nitrosocarbaryl. In this analysis, the cancer potency for N-nitrosocarbaryl was assumed to be linear, and was multiplied by 0.01 to estimate the cancer potency of carbaryl.

Mutagenicity: The Reproductive Effects Assessment Group of EPA concluded that data from mutagenicity studies indicate that carbaryl does not act as a potent mutagen and can be classified as a weak mutagen (EPA, 1988). EPA has concluded that carbaryl does not pose a mutagenic risk because only weak mutagenic responses have been measured and there is no evidence demonstrating the ability of carbaryl to reach germinal tissue; hence, germ cells should not be affected (EPA, 1984).

Diesel Oil

Acute, Subchronic, and Chronic Toxicity: Based on an acute oral LD50 of 9 mL/kg (7,380 mg/kg), diesel oil can be classified as a very slightly toxic compound. A single dermal diesel oil exposure to rabbits resulted in a rating of "extremely irritating" based upon a score of 6.82 (on a scale of 1 to 10), although the irritation may have been caused by additives to the diesel oil for use in internal combustion engines. Diesel oil was nonirritating in primary eye irritation studies. A subacute 3-week dermal study of eight rabbits resulted in an average weight loss of 0.38 kg at the dose level of 4 mL/kg (3,280 mg/kg), and an average weight loss of 0.55 kg with a 67-percent mortality rate at the dose level of 8 mL/kg (6,560 mg/kg). The systemic NOEL for diesel oil used in this risk assessment was 7.38 mg/kg/day on the rat oral LD50 divided by an uncertainty factor of 1,000.

Reproductive/Developmental Toxicity: An inhalation teratology study in which rats were exposed to 101.8 ppm or 401.5 ppm (5.09 or 20.075 uL/kg) of diesel fuel on days 6 through 15 of gestation did not result in any significant teratogenic effects (Macler and Beliles, 1979). The reproductive NOEL for diesel oil used in this risk assessment was 751 mg/kg/day based upon the above inhalation teratology study in rats.

Carcinogenicity: The cancer potency of diesel oil is based on two carcinogenic constituents, benzo-a-pyrene (BaP) and benzene, known to be present in low concentrations in diesel and fuel oils. The potency value used in the risk assessment is 4.9 x 10-6. The derivation of this value is described in detail in Appendix F.

Mutagenicity: Diesel oil is considered mutagenic in this risk assessment because of the presence of polycyclic aromatic hydrocarbons (PAHs) that are known or suspected mutagens. The risk is assumed to be no greater than the risk of cancer.

Kerosene

Acute, Subchronic, and Chronic Toxicity: Based on an acute oral LD50 of 28,000 mg/kg in rats, kerosene is classified as very slightly toxic. It is mildly irritating to the skin and eyes and irritating to the lungs. The systemic NOEL of 28 mg/kg/day was based on the LD50 divided by 1,000.

Reproductive and Developmental Toxicity: The kerosene reproductive NOEL of 751 mg/kg/day is based on the diesel oil reproductive NOEL because no reproductive data exist for kerosene and it is similar in composition to diesel oil.

Carcinogenicity: The carcinogenic potential of kerosene is similar to that of diesel oil since the same substances (BaP and benezene) are responsible in both cases. Kerosene's carcinogenicity is assumed to be the same as that of diesel oil.

Mutagenicity: Kerosene was nonmutagenic both with and without metabolic activation in the Ames bacterial and the mouse lymphoma assays (Conaway et al., 1982). Kerosene also was nonmutagenic in the rat cytogenetic bone marrow assay (Conaway et al., 1982). However, because it contains polycyclic aromatic hydrocarbons (PAH's), as diesel oil does, it is assumed to present a mutagenic risk in this risk assessment.

Bacillus Thuringiensis

Acute, Subchronic, and Chronic Toxicity: No deaths were reported among mice when *B.t.* was administered orally at 0.3 and 1.5 x 106 spores per gram (Kimura 1970, as cited in Sassaman, 1987). The toxin in this formulation was not specified. Hernandez and Mclean (undated, as cited in Sassaman, 1987) administered *B.t.* spores to rats in their feed for 1 day. No deaths, adverse effects on body weight gain, or abnormalities in blood counts were observed among the treated animals during a 13-day observation period. The test material in this study may have contained beta-exotoxin as a toxic agent.

No irritation was observed 3 days after a 20-percent suspension of Dipel was applied to either shaved unabraded or shaved abraded skin of the rabbits (Kimura, 1980 as cited in Sassaman, 1987). Skin irritation was observed in the form of erythema and eventual dry skin and sloughing, leaving a smooth hairless treatment area, following application of Dipel 4L to the skin of rabbits at 7,200 mg/kg in an acute dermal toxicity study (Abbott, 1986, cited in Sassaman, 1987). No mortalities were observed among an unspecified number of mice or rats 7 days after they were exposed to an aerosol of a 20-percent suspension of Dipel for 10 minutes (Kimura, 1970, as cited in Sassaman, 1987). No acute eye irritation was observed in rabbits following ocular instillation of 0.1 ml of a 10-percent suspension of Dipel (Kimura, 1970, as cited in Sassaman, 1987).

In a 13-week Dipel feeding study conducted by Olson and Kwapien (1973, as cited in Sassaman, 1987), 10 rats per group were administered 0.84 mg/kg for 1 week, then 8.4 mg/kg for 12 weeks (Group 1); and 8.4 mg/kg for 1 week, then 8,400 mg/kg for 12 weeks (Group 2). A third group served as the untreated control group. No significant findings were observed in hematology, clinical chemistry, or urinalysis evaluations. In addition, there were no abnormal findings in the gross pathology or histopathology evaluations.

Biotrol was administered in the diet to groups of 20 rats at dietary levels of 1, 1.25, 5, and 10 percent for 49 days (Forsberg et al., 1976, as cited in Sassaman, 1987). No significant differences were observed between treated and control groups of animals. Administration of Biotrol (25 x 109 spores per gram) at a 1 percent level in the diet of 25 female and 25 male rats for 2 years revealed no significant differences between control and treated groups of animals (Barnes, 1970, as cited in Sassaman, 1987).

Reproductive/Developmental Toxicity: The literature contains no data about the reproductive or teratogenic effects of *B.t.*

Carcinogenicity: The literature contains no data about the carcinogenic potential of *B.t.*

Mutagenicity: Growing root stems of *Allium cepa, A. savivum,* and *Vicia faba* were exposed to delta-endotoxin protein. All test materials were negative in all systems (Panda et al., 1979, as cited in Sassaman, 1987).

Quality of the Toxicity Data

The quality of the toxicity data for the spruce budworm chemicals and *B.t.* is listed in Table IV-XI. The quality of the toxicity data base for carbaryl is adequate. Sufficient data exist from available studies to evaluate all toxicity endpoints. Based upon the carbaryl toxicity one-liner (EPA, 1988), no mutagenicity studies for DNA damage have been validated. No other data gaps exist for carbaryl.

Data on diesel oil and kerosene are not available for most toxicity endpoints. The quality of the data base for these two petroleum distillates must be considered only marginally adequate.

Data do not exist for a number of toxicity endpoints for *Bacillus thuringiensis*. The quality of the data base for *B.t.* must also be considered inadequate.

Exposure Analysis

Margins of safety (MOS') were computed for workers and the public for routine operations (typical and worst-case exposures), and for accidents, for carbaryl, diesel oil, kerosene, the combined petroleum distillates, and for *B.t.* Tables IV-XII through IV-XVI list the computed MOS' for these materials. The margins of safety were computed by dividing the laboratory-determined NOEL's in Table IV-X by the doses listed in the risk assessment (Appendix F).

Risk To The Public From Routine Operations

Tables IV-XII through IV-XVI show that margins of safety for the public in routine-typical spraying are

Table IV-XI

Quality of the Toxicity Data Base

Compound	Acute Toxicity	Systemic	Toxicity Endpoint Reproductive Effects	Toxicity Endpoint Cancer	Mutagenicity
Carbaryl	A	A	A	A	M
Diesel Oil	A	M	M	I	M-I
Kerosene	A	M	I	I	I
B.t.	A	M	I	I	M-I

A - Adequate -- adequate information available. More studies unlikely to change assessment.
M - Marginal -- but usable information available for evaluating toxicity. Additional studies may significantly change assessment.
I - Inadequate -- inadequate information available for evaluating toxicity.

greater than 100 for systemic effects for the three chemicals, for the combined petroleum distillates, and for *B.t.* Margins of safety for reproductive effects for the three chemicals also are all greater than 100. These large margins of safety mean that members of the public could be repeatedly exposed to these levels and suffer no adverse effects.

These results indicate that no systemic or reproductive effects are likely to result from the use of carbaryl or *B.t.* in spruce budworm suppression operations.

The routine worst-case scenarios were intended to indicate the upper bounds for public exposure to insecticide applications in the Pacific Northwest. The low probability of occurrence of each assumed event must be emphasized. It is extremely unlikely that anyone would receive a dose as high as those estimated here.

Tables IV-XII through IV-XVI show that MOS's for reproductive effects are greater than 100 for diesel oil, kerosene and *B.t.* for the routine worst-case exposures. Margins of safety for reproductive effects for carbaryl in the worst case are less than 100 for dermal and inhalation exposure from drift, eating fish, and cumulative exposures to the fisherman. Margins of safety for systemic effects projected under this routine worst-case scenario are greater than 100 for carbaryl and kerosene. MOS's for diesel oil and the combined petroleum distillates are greater than 100 except for dermal and inhalation exposure to drift. These results indicate there is some slight risk of effects from carbaryl drift and from diesel oil/petroleum distillate drift exposure.

Margins of safety for persons drinking contaminated water from runoff in The Dalles watershed analysis are listed in Table F4-10 of the risk assessment, Appendix F. None of the MOS' are lower than 100 for any of the feeder streams. MOS' are greater than 1,000 for the reservoir itself, so there is little risk from runoff when large areas of a watershed are sprayed, even when rain occurs immediately after spraying.

Margins of safety for persons eating crops irrigated with contaminated water are given in Table F4-11 of Appendix F. MOS' are all greater than 100, indicating very low risk from this potential route of exposure.

Table IV-XVII summarizes the risk to the public from direct exposure to aerial spray, from eating food directly hit at the highest application rate, and from drinking water that has received a dump of 200 gallons of spray mix.

The extent of effects would depend upon an individual's duration of exposure and any precautionary measures that were taken. For example, if people gathered a bushel of berries from a spray area, did not wash them but froze them, and then ate them every day for a month, they might experience ill effects such as nausea and dizziness. However, if people bathed after being in the forest or washed food items before eating them, the doses would drop (and thus substantially increase the margins of safety).

Table IV-XII

Carbaryl Margins of Safety

	Systemic		*Reproductive*	
	Typical Exposures	**Worst-case Exposures**	**Typical Exposures**	**Worst-case Exposures**
PUBLIC				
Dermal				
Veg. Contact	3,200	3,200	3,200	3,200
Dermal & Inhalation				
Drift	240	76	240	76
Dietary				
Water	10,000	3,200	10,000	3,200
Fish	280	92	280	92
Meat	10,000	2,800	10,000	2,800
Peas or Beans	1,300	500	1,300	500
Berries	2,600	960	2,600	960
Cumulative				
Fisherman	250	87	250	87
Hunter	1,100	490	1,100	490
WORKERS				
Pilot	830	430	830	430
Mixer/loader	370	140	370	140
Observer	240	76	240	76
Card Checker	180	89	180	89
E.E. Team	750	190	750	190
Backpack	79	16	79	16
ACCIDENTS				
Spill onto Worker		-17 1/		-130
Broken Hose		-63		-63
Direct Spray - Adult		45		45
Direct Spray - Child		30		30
Peas or Beans		300		300
Spill into Water				
200 Gallons into Pond		4.8		4.8

Note: Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 10.0 and a reproductive NOEL of 10.0.

1/ When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

MOS rounded to nearest significant digit.

Table IV-XIII

Diesel Oil Margins of Safety

	Systemic		*Reproductive*	
	Typical Exposures	**Worst-case Exposures**	**Typical Exposures**	**Worst-case Exposures**
PUBLIC				
Dermal				
Veg. Contact	8,100	4,100	10,000	10,000
Dermal & Inhalation				
Drift	600	98	10,000	9,900
Dietary				
Water	8,700	1,400	10,000	10,000
Fish	2,700	430	10,000	10,000
Meat	10,000	2,300	10,000	10,000
Peas or Beans	1,100	220	10,000	10,000
Berries	2,200	420	10,000	10,000
Cumulative				
Fisherman	1,600	300	10,000	10,000
Hunter	1,300	260	10,000	10,000
WORKERS				
Pilot	2,100	550	10,000	10,000
Mixer/loader	950	180	10,000	10,000
Observer	600	98	10,000	9,900
Card Checker	450	110	10,000	10,000
E.E. Team	75	28	7,700	2,900
Backpack	200	21	10,000	2,100
ACCIDENTS				
Spill onto Worker		-99 [1/]		1.0
Broken Hose		-49		2.1
Direct Spray - Adult		58		5,900
Direct Spray - Child		39		4,000
Peas or Beans		130		10,000
Spill into Water				
200 Gallons into Pond		2.1		210

Note: Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 7.38 and a reproductive NOEL of 751.

[1/] When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

MOS rounded to nearest significant digit.

Table IV-XIV

Kerosene Margins of Safety

	Systemic		*Reproductive*	
	Typical Exposures	**Worst-case Exposures**	**Typical Exposures**	**Worst-case Exposures**
PUBLIC				
Dermal				
Veg. Contact	10,000	10,000	10,000	10,000
Dermal & Inhalation				
Drift	8,100	1,300	10,000	10,000
Dietary				
Water	10,000	10,000	10,000	10,000
Fish	10,000	5,600	10,000	10,000
Meat	10,000	10,000	10,000	10,000
Peas or Beans	10,000	2,900	10,000	10,000
Berries	10,000	5,500	10,000	10,000
Cumulative				
Fisherman	10,000	4,000	10,000	10,000
Hunter	10,000	3,500	10,000	10,000
WORKERS				
Pilot	10,000	7,200	10,000	10,000
Mixer/loader	10,000	2,400	10,000	10,000
Observer	8,100	1,300	10,000	10,000
Card Checker	6,100	1,500	10,000	10,000
E.E. Team	1,000	370	10,000	9,978
Backpack	2,700	280	10,000	7,400
ACCIDENTS				
Spill onto Worker		-26 1/		1.0
Broken Hose		-3.7		7.2
Direct Spray - Adult		770		10,000
Direct Spray - Child		510		10,000
Peas or Beans		1,700		10,000
Spill into Water				
200 Gallons into Pond		27		730

Note: Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 28 and a reproductive NOEL of 751.

1/ When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

MOS rounded to nearest significant digit.

Table IV-XV

Petroleum Distillate: Diesel Oil + Kerosene Margins of Safety

	Systemic		*Reproductive*	
	Typical Exposures	**Worst-case Exposures**	**Typical Exposures**	**Worst-case Exposures**
PUBLIC				
Dermal				
Veg. Contact	6,300	3,200	10,000	10,000
Dermal & Inhalation				
Drift	470	76	10,000	7,700
Dietary				
Water	6,800	1,100	10,000	10,000
Fish	2,100	330	10,000	10,000
Meat	10,000	1,800	10,000	10,000
Peas or Beans	870	170	10,000	10,000
Berries	1,700	320	10,000	10,000
Cumulative				
Fisherman	1,300	240	10,000	10,000
Hunter	1,000	200	10,000	10,000
WORKERS				
Pilot	1,700	420	10,000	10,000
Mixer/loader	740	140	10,000	10,000
Observer	470	76	10,000	7,700
Card Checker	350	88	10,000	8,900
E.E. Team	59	22	6,000	2,200
Backpack	160	16	10,000	1,700
ACCIDENTS				
Spill onto Worker		-99 [1/]		1.0
Broken Hose		-64		1.6
Direct Spray - Adult		45		4,600
Direct Spray - Child		30		3,100
Peas or Beans		100		10,000
Spill into Water				
200 Gallons into Pond		1.6		160

Note: Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 7.38 and a reproductive NOEL of 751.

[1/] When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

MOS rounded to nearest significant digit.

Table IV-XVI

Bacillus thuringiensis Margins of Safety (Systemic Effects Only)

	Typical	Worst-case
Public		
Inhalation[1/] (Drift)	5,000	1,900
Dietary [2/]		
Water	10,000[3/]	10,000
Peas or Beans	10,000	10,000
Berries	10,000	10,000
Cumulative		
Hunter	10,000	10,000
Workers		
Pilot[1/]	10,000	6,100
Mixer/loader [1/]	8,200	3,800
Observer [1/]	5,000	1,900
Accidents		
Direct Spray of Garden Vegetables	NA	6,700
Spill into Pond	NA	110

[1/] Based on 1.4 mg/kg/da/ for human volunteer inhalation.

[2/] Based on 500 mg/kg/day for rats feeding on 1 percent Biotrol in their diets.

[3/] MOS's greater than 10,000 are listed as 10,000.

NA = Not applicable.

MOS rounded to nearest significant digit

Again, it must be noted that these are one-time, rather than repeat or chronic exposures, and comparison of these doses with the acute LD_{50}'s shows no one is at risk of fatal effects.

Risk To Workers From Routine Operations

In the routine-typical exposures, all categories of workers, except backpack applicators, applying carbaryl, kerosene, and B.t. have MOS's greater than 100. This indicates that backpack workers chronically exposed may suffer ill effects. The efficacy evaluation (E.E.) team members had an MOS less than 100 for diesel oil and for the combined petroleum distillates. This means that unprotected E.E. team members who routinely apply carbaryl may experience some toxic effects from the kerosene-diesel oil mixture.

As summarized in Table IV-XVIII, carbaryl, diesel oil, and the combined petroleum distillates have MOS' less than 100 for routine worst-case exposure. The probability of workers receiving repeated daily doses as high as predicted here is extremely low. Therefore, even if a worker felt ill for a day or so from an unusually high dose, permanent damage would be unlikely. Most of the time, workers will be receiving doses less than those predicted in the routine worst-case scenario. Sensitive individual workers would be at greater risk.

It must be emphasized that the routine worker exposures and resultant margins of safety are what could be expected in most spruce budworm suppression programs in the Pacific Northwest for workers not wearing protective clothing or equipment. All of the studies from which the routine-realistic exposures were calculated are based upon workers wearing no protective clothing. The use of protective clothing can substantially reduce worker doses, as shown in field studies of worker exposure, and thereby increase their margins of safety.

Table IV-XVII

Margins of Safety for the Public in Accidents (Systemic Effects Only)

	Adult Sprayed	Child Sprayed	Eat From Sprayed Garden	Drink Water From Pond Spill
Acephate	17.0	11.0	15.0	-4.2
Carbaryl	45.0	30.0	300.0	4.8
Malathion	9.4	6.3	6.8	-9.1
Diesel Oil	58.0	39.0	130.0	2.1
Kerosene	770.0	510.0	1,700.0	27.0
B. thuringiensis	NA	NA	6,700.0	110.0

NA = Not applicable.

MOS rounded to nearest significant digit

Protective clothing can reduce worker exposures by 27 to 99 percent, as shown in a number of relevant field studies (See Appendix F). The calculated doses in the risk assessment were based upon the assumption that workers work with bare hands and wear ordinary work clothing, such as cotton pants and short-sleeve shirts. It is common practice, however, for insecticide applicators to wear clothing that affords more protection. Typical clothing often includes long-sleeve shirts or coveralls, gloves, and hats.

Research has shown that such protective clothing can substantially reduce worker exposure. During insecticide applications to orchards, mixers reduced their exposure by 35 percent and sprayers reduced their exposure by 49 percent by wearing coveralls (Davies et al., 1982).

Dermal doses estimated in this analysis tend to exaggerate the amount that would actually be received because the dermal penetration rates used in the calculations assume no time factor is involved; that is, the chemicals penetrate the skin immediately. In reality, the penetration rates involve a significant time factor because they were derived from studies in laboratory animals over a period of 1 to several days. Thus, workers would have to ignore their own safety and not wash the chemical off to receive doses as high as predicted in these accidents.

Margins of safety for worker accidents are presented in Table IV-XIX. Workers who spill 500 milliliters (about half a quart) of insecticide concentrate or spray mix on their skin may experience acute toxic effects, in particular, high levels of acetylcholinesterase inhibition, if they do not wash the chemical off. In the case of a spill of 500 milliliters of concentrate, the doses approach the LD50, and exceed the LD50 for carbaryl. The diesel oil dose is 10 percent of the LD50; and the kerosene dose, 3 percent of the LD50.

For carbaryl in particular, this represents a clear risk of severe toxic effects if the chemical is not washed off.

Workers are not likely to be affected by carbaryl or kerosene if they are directly sprayed, but they may be affected by diesel oil (MOS = 58) and the combined petroleum distillates in the mixture (MOS = 45).

Risk Analysis

Cancer Risk

A worst-case analysis for cancer was conducted for carbaryl, diesel oil, kerosene, and the petroleum mixture. (There are no data on *B.t.* carcinogenicity, so no quantitative cancer risk assessment could be performed for this material.) The cancer risks for the chemicals are presented in Table IV-XX.

Table IV-XVIII

Summary of Spruce Budworm Insecticide Margins of Safety for Workers in Routine Worst-case Exposures

Chemical	MOS's for Systemic Effects	MOS's for Reproductive Effects
Acephate	MOS's less than 100 for mixer/ loader (51), observer (28), card checker (34), and backpack sprayer (6.1).	MOS less than 100 for backpack sprayer (73).
Carbaryl	MOS's less than 100 for observer (76), card checker (89), and backpack sprayer (16).	MOS less than 100 for observer (76), card checker (89), and backpack sprayer (16).
Malathion	MOS's less than 100 for pilot (86), mixer/loader (29), observer (16), card checker (18), E.E. team (23), and backpack sprayer (3.4).	All greater than 100
Diesel Oil	MOS's less than 100 for observer (98), E.E. team (28), and backpack sprayer (21).	All greater than 100
Kerosene	All greater than 100	All greater than 100
B. thuringiensis.	All greater than 100	All greater than 100

The risks were computed using the following formula:

Cancer risk = cancer potency x lifetime dose

The lifetime doses for each type of exposure were computed as described in Appendix F. The cancer potencies used in the analysis are listed in Table IV-X and their derivation is described in the previous hazard analysis discussion.

Results for carbaryl, diesel oil, kerosene, and petroleum distillates indicate that no member of the public is at a greater than 2.3 in 100 million risk of cancer from routine exposures. Accidental exposures resulting from a spill into a pond present a cancer risk of 1.1 in 10 million for carbaryl, and 6.9 in 10 billion or less for the other chemicals.

Cancer risks to workers for a 30-year work life at various tasks are presented in Table IV-XX. Workers are not at cancer risk greater than 1 in 1 million for any task or chemical. Cancer risks for worker accidents also do not exceed 1 in 1 million for any chemical.

Table IV-XXI presents cancer risks resulting from several familiar hazards and occupational risks. Motor vehicle accidents have a risk of fatality that averages 2 in 10,000 per person each year. Over a 30-year period, the cumulative risk would be 6 in 1,000. A variety of hazards that have an approximate risk of 1 in 1 million include smoking 2 cigarettes, eating 6 pounds of peanut butter, or drinking 40 sodas sweetened with saccharin. Many occupational risks are greater. Working for 30 years in agriculture or construction has a risk of about 1.8 in 100, and in mining and quarrying, the risk is even greater: 3 in 100 over 30 years.

Risk of Effects from *B.t.* Contaminants (Bioburden)

John Ogle of Agriculture Canada (1988) reports a study in which three *B.t.* formulations were tested for contamination with other microorganisms. Dipel contained fecal streptococci at a level of 1 to 10 million per billion international units of *B.t*. The manufacturer, Abbott Laboratories, was alerted and implemented measures that reduced the contaminant to

Table IV-XIX

Worker Margins of Safety From Accidents

	Spill on Worker		Broken Hose		Accidental Spray	
Chemical	Systemic	Repro	Systemic	Repro	Systemic	Repro
Acephate	-340	-29.0	-170.0	-14.0	17.0	200
Carbaryl	-130	-130.0	-63.0	-63.0	45.0	45
Malathion	-1400	-13.0	-310.0	-2.8	9.4	1,000
Diesel Oil	-99	1.0	-49.0	2.1	58.0	5,900
Kerosene	-26	1.0	-3.7	7.2	770.0	10,000
B. Thuringiensis	NA	NA	NA	NA	NA	NA

NA = Not applicable.

a level of less than one thousand per billion international units. The Canadians plan to reduce this to less than 100.

Studies in humans who were administered *B.t.* by various routes (oral, ingestion, inhalation) have indicated no adverse effects at the doses tested (Sassaman, 1987). No definitive proof has been found that current *B.t.* formulations would contribute to the overall bioburden of human disease-causing microorganisms, such as virus or streptococcus. The current situation can be evaluated as follows (USDA, 1988):

In over 18 years of *B.t.* use, there have been no scientifically documented cases or evidence of *B.t.*-caused illness directly attributable to forestry-use situations. This long history of use, and a special study on the health effects of *B.t.* spray programs conducted by the Oregon Department of Human Resource's Health Division between 1985-87, have not resulted in [the identification of] any cause and effect relationships between *B.t.* use and human illness. Thus, they appear to corroborate the apparent safety of this biological pesticide.

Low levels of extraneous microorganisms do exist in *B.t.*; however, these low levels do not affect the overall safety of *B.t.* The same environmental bacteria are also present at similar levels in water, food, milk, and other dairy products. The chances of exposure to low levels of extraneous microorganisms may be greater from eating or drinking ordinary food products than from *B.t.* use in forestry.

Another concern recently expressed was the possibility of enterotoxins being present in *B.t.* products. Manufacturers of *B.t.* products advise us that due to steps taken in the manufacturing process, it is unlikely that enterotoxins would be present in distributed products.

A final concern has been *B.t.* contamination of food or feed. Given current information, and under forestry use conditions, the probability of *B.t.* contaminating food or food products is highly unlikely. During all the years of *B.t.* use in agriculture and forestry, no evidence has been seen that *B.t.* grows on food, produces enterotoxins, significantly increases the bioburden, or causes unacceptable contamination.

Thus, it appears that humans exposed to *B.t.* in spruce budworm suppression operations may be at some low level of risk from eye or skin irritation or infection, but are not at risk of any systemic effects from *B.t.*

Risk of Heritable Mutations

No human studies are available that associate the insecticides in this analysis with heritable mutations. Furthermore, no risk assessments that quantify the probability of mutations from the insecticides are

Table IV-XX

Cancer Risk Compared to $1x10^{-6}$ (1 in 1 million) Acceptable Risk Level

	Carbaryl	Diesel	Kerosene	Petroleum Distillates
PUBLIC				
Dermal & Inhalation				
Drift	No Risk	3.6E-11	1.0E-11	4.6E-11
Dietary				
Water	6.4E-10	2.5E-12	7.1E-13	3.2E-12
Fish	2.2E-08	8.1E-12	2.3E-12	1.0E-11
Meat	6.0E-10	1.4E-12	4.1E-13	1.8E-12
Peas or Beans	4.8E-04	1.8E-11	5.1E-12	2.3E-11
Berries	2.4E-09	9.1E-12	2.6E-12	1.2E-11
Cumulative				
Fisherman	2.3E-08	1.2E-11	3.6E-12	1.6E-11
Hunter	3.7E-09	1.5E-11	4.3E-12	1.9E-11
WORKERS				
Pilot	No Risk	3.2E-10	9.0E-11	4.1E-10
Mixer/loader	No Risk	7.9E-10	2.2E-10	1.0E-09
Observer	No Risk	1.3E-09	3.7E-09	1.7E-09
Card Checker	No Risk	1.5E-09	4.3E-10	1.9E-09
E.E. Team	No Risk	8.1E-09	2.3E-09	1.0E-08
Backpack	No Risk	9.8E-10	2.8E-10	1.3E-09
ACCIDENTS				
Spill onto Worker	No Risk	1.4E-07	1.4E-07	1.4E-07
Broken Hose	No Risk	7.0E-08	2.0E-08	9.0E-08
Direct Spray--Adult	No Risk	2.4E-11	7.0E-12	3.1E-11
Direct Spray--Child	No Risk	3.6E-11	1.0E-11	4.7E-11
Direct Spray -- Garden Vegetables	1.8E-09	1.1E-11	3.2E-12	1.4E-11
Spill into Pond --200 Gallons	1.1E-07	6.9E-10	2.0E-10	8.8E-10

No Risk - No risk for carbaryl exposure by other than oral route.

Table IV-XXI

Lifetime Risk of Death or Cancer Resulting From Everyday Activities

Activity	Need to Accumulate a One-in-one Million Risk of Death[1/]	Average Annual Risk Per Capita [2/]
GENERAL RISKS		
Motor vehicle accident	1.5 days	2×10^{-4}
Falls	6 days	2×10^{-5}
Drowning	10 days	4×10^{-5}
Electrocution	2 months	5×10^{-6}
Lightning	2 years	5×10^{-7}
OCCUPATIONAL RISKS		
Mining and quarrying	9 hours	1×10^{-3}
Agriculture	15 hours	6×10^{-4}
Manufacturing	4.5 days	8×10^{-5}
Trade	7 days	5×10^{-5}
Firefighting	11 days	8×10^{-4}

[1/] Based on living in the United States

[2/] Numbers shown exponentially in this table are to be interpreted as follows:

1×10^{-3} means 1 in a thousand.
1×10^{-4} means 1 in ten thousand.
1×10^{-5} means 1 in one hundred thousand.
1×10^{-6} means 1 in a million.
1×10^{-7} means 1 in ten million.

available in the literature or from EPA. Laboratory studies constitute the best available information on mutagenic potential. Results of the mutagenicity assays conducted on the three insecticides are summarized in Table 2-4 of Appendix F.

For some of the insecticides, no acceptable mutagenicity tests exist. For these insecticides, a worst-case assumption is made that these insecticides have the potential to cause mutations in humans. In these cases, the results of carcinogenicity tests or cancer risk assessments can be used to estimate the worst-case risk for mutagenicity. The rationale for this assumption is summarized by the USDA (1985) as follows:

Since mutagenicity and carcinogenicity both follow similar mechanistic steps (at least those that involve genetic toxicity), the calculated risk of cancer can be used as a worst-case approximation of somatic cell mutation risk. The basis for this assumption is that both mutagenicity, and at least primary carcinogens, react with DNA to form a mutation or DNA lesion affecting a particular gene or set of genes. The genetic lesions then require specific metabolic processes to occur, or the cells must divide to insert the lesion into the genetic code of the cell.

We believe the cancer risk provides a worst-case approximation to heritable mutations because:

1. All chemicals known to induce heritable germ cell mutation in mammals also produce cancer in mammals, and almost always at a lower total dose.

2. Many chemicals that are carcinogens in rodents fail to induce heritable germ cell mutations, even at the maximum tolerated dose (MTD).

3. Mammalian meiotic processes in gonadal tissue appear to be much more efficient in eliminating DNA lesions than somatic cells.

4. Human epidemiology studies of populations exposed to genotoxic carcinogens (radiation exposures in Nagasaki and Hiroshima) have demonstrated significant induction of cancer but no evidence of heritable mutations.

Carbaryl was nonmutagenic in the majority of assays conducted and was nononcogenic in all of the carcinogenicity tests performed; therefore, it can be assumed that its germ cell mutagenic risk is slight to negligible. Kerosene and diesel oil both contain PAH's and are considered to be possibly mutagenic.

Other Possible Effects of the Insecticides

Synergistic effects of chemicals are those that occur from exposure to two or more chemicals either simultaneously or within a relatively short period of time. For example, forestry workers exposed to the fungicide, thiram, have experienced skin blotching and nausea from drinking alcoholic beverages within 10 days of their thiram exposure. Synergism occurs when the combined effects of the two chemicals cannot be predicted based upon the known toxic effects of the individual chemicals, or when their combined effect is much greater than the sum of the effects of each agent alone. For example, a mixture of the herbicides 2,4-D and picloram has produced skin irritation in test animals while neither insecticide alone has been found to be a skin irritant. Cigarette smoke and asbestos are both known carcinogens. When inhaled in combination, they have been found to increase cancer risk eightfold above the risk of persons exposed to asbestos who do not smoke.

Simultaneous exposure to more than one chemical is likely in cases where those chemicals are combined in a single spray mixture, such as the carbaryl-diesel oil mixture.

The EPA guidelines for assessing the risk from exposures to chemical mixtures (EPA, 1986a) recommend using additivity models when little information exists on the toxicity of the mixture and when components of the mixture appear to induce the same toxic effect by the same mode of action. They suggest in their discussion of interactions (synergistic or antagonistic effects) of chemical mixtures that "there seems to be a consensus that for public health concerns regarding causative (toxic) agents, the additive model is more appropriate than any multiplicative model." Since carbaryl's effect is chiefly cholinergic, and diesel and kerosene are systemic toxicants, their effects were not considered additive. The evaluation of petroleum distillates assumed an additive model for the effects of kerosene and diesel oil in the Sevin 4-Oil mix.

If the response of a population of test animals to varying doses of a chemical follows a normal distribution (bell-shaped curve), the hypersensitive individuals are those on the left-hand side of the curve that respond at much lower doses than the average. A safety factor of 10 has traditionally been used by regulatory agencies (National Academy of Sciences [NAS], 1977) to account for this intraspecies (interindividual) variation. Not all sensitive individuals will be covered by an MOS of 100 because human susceptibility to toxic substances can vary two to three orders of magnitude (Calabrese, 1985). (These individuals could correspond to the very tail of the bell-shaped curve.)

Factors that may affect individual susceptibility to toxic substances include diet, age, heredity, preexisting diseases, and life style (Calabrese, 1978). These factors have been studied in detail for very few cases, and their significance in controlling the toxicity of the proposed insecticides is unknown. However, enough data have been collected on other chemicals to show that these factors can be important.

Genetic factors also are known in some cases to be important determinants of susceptibility to toxic environmental agents (Calabrese, 1984). Susceptibility to irritants and allergic sensitivity vary widely among individuals and is known to be largely dependent upon genetic factors. Race has been shown to be a significant factor influencing sensitivity to irritants, and some investigations have indicated that women may be more sensitive than men (Calabrese, 1984).

Persons with other types of preexisting medical conditions also may be at increased risk of toxic effects. For example, sensitivity to chemical skin irritants can be expected to be greater for people with a variety of chronic skin ailments. Individuals who are immunosuppressed due to illness or from therapeutic treatment may be susceptible to microbial agents not known to be infectious to normal individuals. Patients with these conditions may be advised to avoid occupational exposure to irritating chemicals or *B.t.* (Shmunes, 1980, as cited in Calabrese, 1984).

A particular form of sensitivity reaction to a foreign substance is allergic hypersensitivity. Except for contact dermatitis in delayed allergic reactions, these are responses to high molecular weight organic molecules or whole cells. None of the insecticides in the Forest Service spruce budworm suppression program is of high molecular weight, so the immediate allergic reactions and the delayed allergic reactions,

except for contact dermatitis, can be ruled out as possible toxic effects. Contact dermatitis may be induced by lower molecular weight substances, such as the catechols of poison ivy, cosmetics, drugs, or antibiotics (Volk and Wheeler, 1983). Benzocaine, neomycin, formaldehyde, nickel, chromium, and thiram are all known to produce these reactions (Marzulli and Maibach, 1983).

A series of dermal sensitization studies showed no evidence that *B.t.* could induce allergic hypersensitivity (Fisher and Rosner, 1959 as cited in Sassaman, 1987).

Based upon the current state of knowledge, individual susceptibility to the toxic effects of the insecticides cannot be specifically predicted. As discussed above, safety factors have traditionally been used to account for variations in susceptibility among people. The margin-of-safety approach used in the risk assessment takes into account much of the variation in human response, as discussed earlier by Calabrese (1985). As described in the introduction to the risk assessment, a safety factor of 10 is used for <u>inter</u>species variation; an additional safety factor of 10 is used for <u>intra</u>species variation.

Thus, the normal margin of safety of 100 for both types of variation is sufficient to ensure that most people will experience no toxic effects. However, unusually sensitive individuals may experience effects even when the margin of safety is equal to or greater than 100.

Some people may develop contact dermatitis from insecticide exposure. However, the small, infrequent exposures of the public should limit the possibility of their experiencing this type of reaction.

Inert ingredients are chemicals that are added to the active ingredient to prepare a pesticide formulation. Inert ingredients provide a carrier for the active ingredient that facilitates the effective application of the pesticide, but is not intended to supplement the pesticide's toxic properties. The single inert of concern in this analysis, kerosene, has been fully analyzed in the risk assessment.

In a given year, up to approximately 1,350 square miles (850,000 acres) might be treated with insecticides for budworm suppression. The treated area would thus comprise less than 1 percent of the total land area of the two States. Moreover, the treatments would occur, for the most part, in the remote areas of these densely forested lands. In general, treatment units are sprayed only once in a given year, then not treated again until a number of years later. The later treatment also may be with a different insecticide.

No individual member of the public is likely to receive repeated exposures to any of the insecticides because of the remoteness of most treatment units, the widely spaced timing of repeated treatments, and the use of a variety of insecticides for different purposes. In addition, the precautions taken by the Forest Service in their treatment operations make any dose at all to the public unlikely.

Summary Of Human Health Effects Of The Alternatives

Alternative A - No Action

This alternative would have no effect on human health because no chemical insecticides or biological controls would be used.

Alternative B

This alternative presents the lowest risk of all the alternatives except the No-action Alternative. *B.t.* appears to present little risk of acute or chronic health effects, although there is a general lack of data on reproductive, cancer, and other toxicity endpoints. Should data become available in these areas, the use of *B.t.* would be reassessed. Because Abbott Laboratories has reduced the presence of other microorganisms in its *B.t.* formulation, there appears to be little risk of any public health effects from bioburden in their product.

Alternative C

Carbaryl poses a human health risk only in the case of accidents. The petroleum distillates, kerosene and diesel oil, associated with carbaryl application do present a risk under routine worst-case conditions and in accidents. Therefore, this alternative presents the highest risk to human health of the five alternatives. The petroleum distillates present a degree of uncertainty in the risk evaluation because of lack of data on their toxicity. Should additional data become available, their risks would be reassessed.

Alternative D and E

Human health risks of this alternative would be intermediate between Alternatives B and C. Risks would be reduced to the extent that *B.t.* is used instead of carbaryl.

Mitigating Measures

For any project that is implemented, a public information plan would be developed to ensure that timely notification is given about when and where spray operations would take place. Two general groups would need notification, the general public and

organizations that may have people working or recreating in the area. Members of the public would be given the opportunity to receive individual notice if they make a special request. Warning signs which are posted on the perimeter of treatment units would be bilingual (English and Spanish).

Economic Efficiency And Local Impacts

Western spruce budworm infestations are a natural component of the biological environment of western coniferous forests. Epidemic infestations of budworm can, over time, alter the forest resource characteristics. Impacts of budworm populations can directly influence the future output of forest resources. Resources may be diminished or enhanced, depending on the severity of the infestation and the type and condition of the resources which are affected.

Forest resources are managed to provide wildlife habitat, water, raw materials, scenic beauty and many other human benefits. Protection of these resources, as well as the output of forest products, is a primary responsibility of land managers. The level of protection from forest pests which is to be provided is a resource allocation decision. The decision maker must weigh the social benefits of lessening undesirable resource impacts, against the costs of resource protection and any possible adverse economic, social, and environmental effects.

One purpose of this economic analysis is to assign value to identified and quantified effects (both benefits and costs) which result from spruce budworm infestations, whether or not the outbreak is treated. Economic effects may be expressed in either dollar or nondollar values and can be classified into two categories: real and pecuniary (Musgrave and Musgrave, 1973). Both categories have a benefit and cost dimension.

Real effects refer to those impacts that have the potential to change the material well-being of society. The loss of standing mature timber or fish habitat, for example, are real effects of significant resource damage. Important in this analysis is the identification and social valuation of material resources expended (cost), and resources preserved or produced (benefits) by a pest management activity.

Direct control is considered economically efficient when benefits that can be valued exceed costs of suppression. The ratio of benefits to costs (benefit-cost ratio) is used to compare the relative cost efficiency of treating analysis units. Units with benefit-cost ratios greater than 1.0 are considered cost-efficient investments. The larger the benefit-cost ratio expressed for an analysis unit, the more attractive is the investment opportunity.

An action Alternative would result in both short- and long-term local economic impacts. These impacts are typically measured by changes in income, earnings, employment opportunities, commodity output, and other economic and financial conditions.

Local economic impacts reflect both real and pecuniary effects. Pecuniary effects are benefits and costs that accrue locally, but occur at the offsetting expense or gain to other locations. By definition, they do not contribute to the material welfare of society as a whole, although they may be socially desirable. Pecuniary effects reflect shifts of material well-being from one part of society to another, and between individuals and locations. Society's concern with an equitable distribution of benefits and costs, and the impacts of changing levels of economic activity on local and regional communities; often necessitate an examination of pecuniary effects. Changes in wage rates, income, earnings, employment, output, and price levels are frequently used to measure pecuniary effects and local economic impacts. Also, positive pecuniary effects or local impacts may result regardless of whether or not an Alternative is economically efficient.

Methods

The methods used to quantify and value changes in forest resource output flows and other information pertinent to the economic analysis are further explored in Appendix E. These methods are specifically tailored to valuing the resource effects identified in the Environmental Consequences section of the EIS. Each analysis unit in the site-specific EA(s) will be assessed for relative economic efficiency, by examining the relationship between their respective predicted benefits and costs. Economic efficiency criteria are presented to assist decisionmakers in selecting units for application of a pest management Alternative (which includes the No Action Alternative).

In some instances, there is insufficient information to quantify the immediate biological effects of the infestation or treatment measures, and there is no method for projecting eventual resource output changes. There is no basis for evaluating the economics of these biological effects. The implications of these situations can only be considered in a qualitatively.

Alternative A - No Action

Under the No Action Alternative, a long-term reduction in the future supply of fiber is projected for most analysis units. Some areas affected by the

epidemic could sustain small areas of substantial mortality. To the extent this leads to timber salvage sales and subsequent processing of timber, local economic activity would increase over the short term.

The No Action Alternative would require no investment expenditures for direct control. No benefits would result in terms of averted losses. The economic loss associated with No Action is the benefit to be ascribed, in part or whole, to an action Alternative.

Alternatives B, C, D and E

To the extent funding is available, investment in direct suppression with *B.t.* or carbaryl would be made in analysis units which offer the greatest net financial and intangible benefits. Total net benefit accruing to any of these Alternatives is a measure of economic efficiency which indicates an improvement in the Nation's material well-being.

Direct suppression would also lead to various economic impacts. In the short term, project expenditures in regional and local trade, services, and other economic sectors would bolster economic activity. Over the longer term, a pest management Alternative would ensure the future availability of a greater supply of timber for local processing industries. This result would set the stage for higher levels of future local economic activity which, in turn, would produce other beneficial regional and community effects.

Social Factors

The effects of implementation of any Alternative on consumers, citizens' civil rights, minority groups, and women are estimated to be insignificant. Generally, these effects are related to the supply of wood fiber and the resulting cost of wood products. Primary and secondary employment associated with the manufacture of wood products is also a consideration.

Short-term Use Versus Long-term Productivity

"Short-term" uses are generally those that determine the present quality of life for the public. Short-term uses of Forests in the Pacific Northwest Region typically include timber harvest, recreation, livestock grazing, transportation, utility corridors, and wildlife habitat. Decisions about these short-term uses are usually made through each National Forest Land and Resource Management Plan.

Compared to all activities that take place in a Forest, a relatively narrow spectrum of management activities is considered in this EIS. Pest management helps provide the flow of goods and services associated with the short-term uses of a Forest. The processes presented here for managing spruce budworm--and many of the mitigation measures--are designed to protect the long-term productivity of the land.

"Long-term productivity" refers to the capability of the land to support sound ecosystems which produce resources such as forage, timber, wildlife, and water. Management activities associated with short-term uses (for example burning, use of machinery, or removal of woody debris) may reduce the productivity of National Forests somewhat. How much the long-term productivity is reduced is not known, because investigations of these effects have only recently begun.

The insecticides examined in the EIS have no known effect on long-term productivity. However, it is known that any management activities have the potential to reduce the natural productivity of the land if certain operating guidelines are not followed. Each Forest Plan is developing management Standards and Guidelines designed specifically to protect long-term productivity. In addition, mitigation measures were developed for all management activities considered in this EIS.

The Preferred Alternative could result in adverse effects because of the greater risk of extensive and severe wildfires. Alternative B could have a slight positive effect on long-term productivity because it would reduce mortality without producing a broad impact on beneficial, nontarget invertebrates.

Irreversible Or Irretrievable Effects

No irreversible commitments of resources have been identified. Implementation of the Preferred Alternative would avert most of the total net timber loss which would occur from not treating the infestation. Recouping all of the estimated loss could be accomplished only with a highly successful treatment program which treated all of the infected stands.

Energy Requirements And Conservation Potential

Alternative A - No Action

Energy requirements and conservation potential would be unchanged from those expected in the course of continuing Forest management operations.

Alternatives B, C, D and E

Implementation of these Alternatives would require consumption of fossil fuels by power aircraft and ground-based support vehicles. Except for those minor savings which are possible through conservative use of vehicles, no major opportunities for energy conservation were identified.

Incomplete Or Unavailable Information

Incomplete or unavailable information was a problem sometimes encountered in the process of preparing this EIS. The implications of these problems and how they were handled are discussed here.

The purpose of the environmental analyses contained in this EIS is to "present the environmental impacts of the proposal and the Alternatives in comparative form, thus sharply defining the Issues and providing a clear basis for choice among options by the decisionmaker and the public" (40 CFR 1502.14)

Human health concerns related to managing western spruce budworm by using insecticides is an issue.

A detailed and systematic determination of the quality of available information on the effects of insecticides on human health is identified in the section on Human Health Effects in this Chapter. Information that is incomplete or is not available is discussed in Appendix F.

The costs of obtaining more precise and conclusive data were estimated, but were found to be exorbitant. While there is some incomplete information, much is available and has been discussed and considered in this document. A large portion of the available information was developed in support of registration of insecticides by the Environmental Protection Agency.

Data and other information collected for the analyses in this EIS, as well as the estimates of effect and the conclusions which were drawn, vary in precision and accuracy. Some are based on censuses and many confirming studies. Others are based on samples and a few studies; some are estimates by professional specialists drawing on their experience in individual disciplines. The standard for determining the depth of analysis is that analysis be sufficient to provide "a clear basis for choice among options"--in this case, a choice from the five Alternatives considered in this EIS.

Uncertainty in data and information is often the result of the inherent variability of natural phenomena. Uncertainty due to inherent variability can be expressed through a variety of means, including statistical measures of variation, estimates of ranges, and qualitative descriptions.

Sometimes uncertainty is the result of incomplete or unavailable information. If the information that is incomplete or unavailable is essential to the decision to be made--in this case, selection of one of the five Alternatives considered in this EIS--then a more rigorous standard for analysis and reporting is required (40 CFR 1502.22). The more rigorous standard specifies an orderly, careful, and open professional approach in dealing with uncertainty.

Reasonably Foreseeable Significant Adverse Effects

In preparing this EIS an open, public process was used to identify significant Issues. Those Issues identified are issues because of the potential for reasonably foreseeable significant adverse impacts on the human environment. The potential impacts are in the areas of human health, social and economic effects, and environmental effects. See Chapter I for a discussion of the Issues and the scoping process.

Economic Impacts

Western spruce budworm management will affect the Forest Service's ability to provide goods and services. Predicted decline in forest growth as a result of budworm defoliation can be reasonably estimated. In the area of social and economic effects, there is sufficient information to provide a clear basis for making a choice among options with confidence.

Environmental Impacts

Environmental effects are reasonably well understood. The uncertainty associated with estimating environmental effects is due to the (often great) inherent variability and diversity associated with the natural environment. By using appropriate assumptions and professional judgment, effects of

actions can be reasonably estimated with confidence. (These estimated effects are presented as the main part of this chapter.) While no estimate of effects for a given Alternative is absolutely correct, the relative effects--compared to other Alternatives--are correct. There is sufficient information regarding environmental effects to provide a clear basis for choice among the Alternatives.

Statement Of Relevance

The relative effects of insecticides on human health can be compared among Alternatives. Comparisons are made in this EIS for accidents from spills in a variety of environmental settings. (See the Human Health Effects section of this chapter, and the comparison section of Chapter II.) The uncertainty for which there is incomplete or unavailable information concerns the actual human health risks insecticides might present.

Potential Conflicts With Plans and Policies of Other Jurisdictions

There are no conflicts expected between the Preferred Alternative and the plans and policies of other agencies. The only exception would be the ability of public agencies to participate in cost share agreements with the Forest Service. Under cost share agreements, the Forest Service will only provide funds to cooperators for methods of treatment included in the Preferred Alternative.

Summary Of Information

Information that is currently available is summarized in several places in this EIS:

- Appendix F - Qualitative Health Risk Data
- Appendix F - Hazard Analysis
- Appendix F - Details of Mutagenicity and Carcinogenicity
- Chapter IV - Human Health Effects

Evaluation Of Impacts

The Alternatives' possible effects on human health are compared in Chapter II. The detailed human health effects of the Alternatives are discussed in Chapter IV. Many research studies were reviewed to determine what effects are currently known. A great number of research studies have been conducted on the use of insecticides, many in support of registration by the Environmental Protection Agency. Enough information is available that risk can be reasonably managed for both insecticides being considered (*B.t.* and carbaryl). Quantitative estimates of risk are contained in Appendix F, which is a detailed quantitative human health risk assessment.

Unavoidable Adverse Effects

Implementation of the Preferred Alternative would result in some adverse environmental effects that cannot be avoided. Standards and Guidelines, and the mitigating measures developed in this EIS are intended to keep the extent and duration of these effects within acceptable levels, but adverse effects cannot be completely eliminated.

Because this EIS examines alternative methods for managing western spruce budworm epidemics, its focus is on how these different methods could affect the environment. There are three areas where potentially significant adverse effects might be expected:

1. Human health

2. Fish, wildlife, domestic livestock, and nontarget insects;

3. Economics

The potential for adverse effects varies with each Alternative, and is discussed in detail in this EIS.

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Moth (adult)

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Appendix

Moth (adult)

A: Public Response and Participation

APPENDIX A

PUBLIC PARTICIPATION

This appendix includes: 1) a brief description of public participation activities prior to the publication of the DEIS; 2) the nature and extent of comments; 3) list of respondents to DEIS; 4) public comments and the Forest Service Responses; 5) photocopies of letters.

The Forest Service is directed to respond to public comments by the Council on Environmental Quality Regulations (Section 1503.4) for implementing the provisions of the National Environmental Policy Act.

The actions the Forest Service must consider are modify alternatives including the proposed action. Development and evaluation of alternatives not previously given serious consideration by the agency. Supplement, improve, or modify its' analysis and make factual corrections. Explain why comments do not warrant further agency response.

Summary Of Public Participation Activities

The public's interest in the management of the western spruce budworm situation in Oregon and Washington continues at a high level. The Interdisciplinary (ID) Team used the public involvement process developed in 1986, 1987, and 1988, as the basis for this EIS.

In 1986, an extensive public involvement process was initiated. It included gathering background information from other agencies, newspaper clippings, issues and concerns expressed about past projects, and information on appeals of past decisions. In addition, mailings were conducted, several news releases made, and public meetings held.

In preparing the 1988 Environmental Assessment, a letter was sent to cooperators and all interested individuals on the mailing list, requesting additional input and identification of any new issues and concerns. Based on these responses, it was determined that the major issues and concerns described in the 1986 and 1987 Environmental Assessments were still valid.

Several meetings were held with interested or concerned parties in both Oregon and Washington in 1985, 1986, 1987, and 1988 for additional input. Throughout the fall of 1987 and spring and summer of 1988 several news releases were made regarding the analysis of the western spruce budworm situation.

In May 1988, a brochure was distributed to approximately 2,000 addresses requesting comments and concerns on the current western spruce budworm infestation. The responses to this brochure helped identify issues, concerns, and opportunities used in this Environmental Impact Statement. Press releases were mailed to the news media in the areas with infestations to inform the public of the preparation of this EIS.

An Information Update Letter was mailed to approximately 2000 individuals in October of 1988, and April 1989. These Updates were designed to keep the public informed on planning issues.

In October 1988, a Draft Environmental Impact Statement on the management of the western spruce budworm in Oregon and Washington was released for public review. Approximately 1000 copies of the DEIS and 2000 copies of the summary were mailed to interested parties. The issuance of the DEIS for public review triggered a forty-five day public review period which ended December 22, 1988.

Nature And Extent Of Comments

The Pacific Northwest region received a total of 101 responses containing 103 signatures. Although the official closing date for the review was December 22, 1988. Mail postmarked through January 11, 1989 was accepted.

Seventy-one letters were from individuals acting for themselves. The remaining thirty respondents represented public and private organizations. These came in the form of individually written letters (67), form letters (33), and modified form letters that contained additional remarks written by the respondent (1).

The coding team found 1,244 comments which could be coded for an average of 12 comments per response. Of these, 350 expressed a preference or dislike for a specific alternative. This is shown graphically in Figure A-1. The 1,244 comments were categorized into the following subject areas depending on the types of concern that was expressed.

Human Health Concerns : 98 comments

Environmental Concerns : 95 comments

Resource Concerns : 120 comments

Pest Management Concerns : 328 comments

Planning Concerns : 268 comments

Timber/Forest Management Concerns : 52 comments

Socio-economic Concerns : 66 comments

Recreation Concerns : 3 comments

Misc. Concerns : 51 comments

No Subject Concern Expressed: 163 comments

In addition, Table 1 shows a further breakdown of the subject codes receiving comments and the opinions that were expressed.

The suggestions and comments received were reviewed , analyzed, and considered in preparing the Final Environmental Impact Statement. Substantive comments to the Draft Environmental Impact Statement are shown in the Public Comments and Forest Service Response portion of this appendix. The comments provided by respondents were considered in the preparation of the Final Environmental Impact Statement.

Public Comments And Forest Service Responses

Pest Management

Current Situation identifies infestation on East side, but says nothing about the West Side. Isn't some of the infestation on the West Side?

RESPONSE: Yes, some of the infestation is on the West Side. The document has been amended to reflect this.

The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These reference should be corrected to read 1.0 lb. a.i./acre...

RESPONSE: We have made this change in the text and in the analysis.

If carbaryl is as toxic to insects as stated, it is difficult to understand why only minor effects on natural enemies are expected. Predator populations cycles normally trail prey population cycles; so alternatives which significantly reduce...predators can be expected to increase the severity of future budworm infestations....Furthermore, some native budworm predators may also be effective in controlling other insects which are damaging to forests....Damage to those predatory species could result in increasing damages from other insect pests. Such damages should also be considered in the relative costs of alternatives under consideration.

RESPONSE: We anticipate little or no lag time between the rebound of endemic budworm and predator populations and thus no increased cost. Similarly, predator populations of other pests as well as those pests should be reduced and rebound in conjunction with the budworm predator population.

Equally troubling is an apparent internal contradiction in descriptions of Alternative D. In chapt. II-3, the implication is that Carbaryl would be used as a supplement to the use of *B.t.* with the proviso that "The choice of Carbaryl or *B.t.* over the majority of the treatment area would be determined on a project-specific basis." However, in chapt. IV-18, the document states, "It is assumed *B.t.* will be applied on sensitive areas, e.g. riparian/watershed, and Carbaryl will be used on all other areas." Depending on the parameters used to define sensitive areas, this could mean a far greater application of Carbaryl than might infer from reading the description in chapt. II. Certainly this needs clarification.

RESPONSE: While making projections, we have made the assumption that the worst case scenario is chosen. This will alleviate the possibility that potential impacts might be underestimated.

The Forest Service has found *B.t.* to be a very effective pesticide for controlling the Spruce Budworm. It does not follow that the use of Carbaryl is a preferred alternative.

RESPONSE: Yes, *B.t.* is an effective insecticide for controlling spruce budworm. However, carbaryl is also an effective tool for spruce budworm control. Our preference for both insecticides, as displayed in the DEIS recognizes this.

Any plans to stop the spread west of the cascades? Is it likely to be carried by cars or trucks?

RESPONSE: The budworm does not spread in the manner that some other insects, diseases or weeds

A–I

Total Codable Comments for and Against Each Alternative

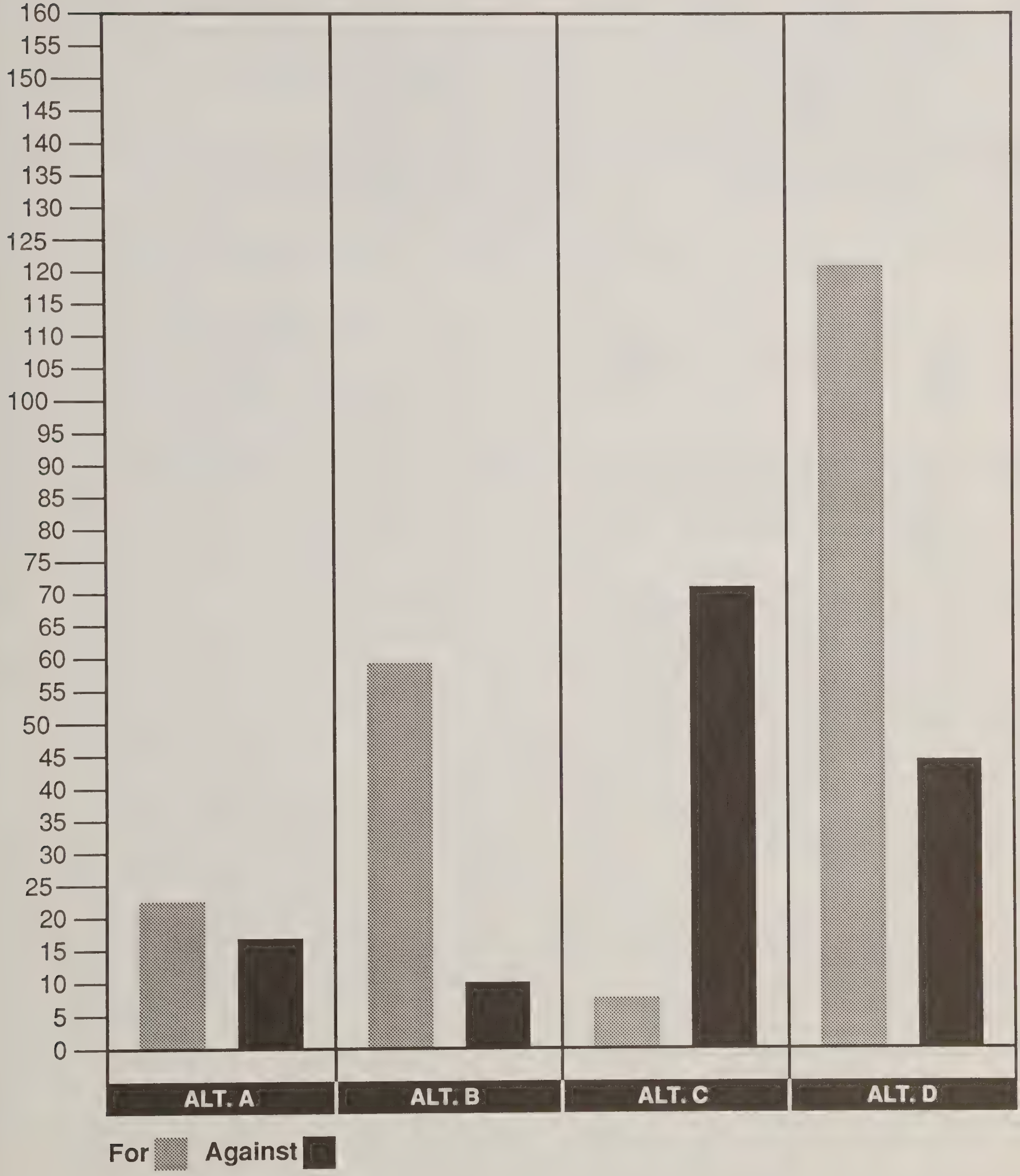

Table A-I

Subject Codes VS Opinions Expressed

	SUBJECT CODES		OPINION CODES
100	Human health concerns	OPN #1	Positive (agrees,likes)
200	Environmental concerns	OPN #2	Negative (disagree,dislike)
300	Resource concerns	OPN #3	Like, but needs modification
400	Pest management (general)	OPN #4	Start or initiate
500	Planning	OPN #5	Ban or eliminate
600	Timber/Forest management	OPN #6	No opinion (opn. not clear)
700	Socio-economic concerns	OPN #7	Acceptable with reservations
800	Recreation	OPN #8	Want less of
900	Misc.	OPN #9	Want more of

SUBJ CODE NUM.	Subject Code Descriptions	TOTAL	OPN #1	OPN #2	OPN #3	OPN #4	OPN #5	OPN #6	OPN #7	OPN #8	OPN #9
515	Applicability of data in the DEIS	67		66				1			
410	Spruce Budworm Management	50	29	2	2			17			
425	Use of chemical treatments(ex.Carbaryl)	44	15	20	3			3	2		1
902	Application rate	38	1	4	30			3			
518	Adequacy of analysis in the DEIS	37	32	4							1
520	Plan conforms to standards & guidelines	34	29	2	2			1			
521	Plan conforms to legal requirements	33	29	3							
512	Comleteness of data in the DEIS	27	1	10	2			1			13
432	Monitoring pest population and spread	24	4	1	1	3		12			3
431	Pest management alternatives	22	9	2	2	1		2			6
423	Known effects acceptable(Pest Mgmt.)	21	17					4			
424	Use of biological treatments (ex. *B.t.*)	21	12					7	2		
442	Swath barrier along rivers, streams,etc.	20	10	4	3			3			
600	Timber/Forest management	19	5	4	2			7			1
723	Cost-benefit analysis of alternative	19	6	3	2			5			3
330	Fish & Riparian concerns	18	14	2				2			
610	Intensive management practices	16	5	3				5			3
525	Adequacy of long term planning	15		7	1			3			4
443	Spray drift effects	14	1	10				3			
223	Known effects (environmental)	14	5	7				2			
517	Thoroughness of analysis in the DEIS	13	3	5							5
400	Pest management	12	4	3	2			2			1
412	Completeness of data	12	1	3				1			7
449	Risks associated w/accidents acceptable	12	3	6		1		1			1
417	Thoroughness of analysis	11	2	5	2						2
435	Non-interference of natural processes	11	6	2				3			
615	Long term productivity goals	11	7		1			3			
263	Known effects (of B.t. on environment)	11	6	3	1			6			
200	Environmental concerns	11	9							2	

Table A-I

Subject Codes VS Opinions Expressed (Continued)

SUBJ CODE NUM.	Subject Code Descriptions	TOTAL	OPN #1	OPN #2	OPN #3	OPN #4	OPN #5	OPN #6	OPN #7	OPN #8	OPN #9
150	Human health concerns-biological agents	10	9			1					
516	Accuracy of analysis in the DEIS	10	1	6							3
901	Non-treatment areas	10		3	5	1		1			
100	Human health concerns (general)	9	8					1			
124	Insecticides are a carcinogenic risk	9	2	3	2			2			
360	Wildlife concerns	9	5	3				1			
373	Known effects acceptable (on wildlife)	9	5	4							
426	Use of broad spectrum insecticides	9		7				2			
127	Carbaryl as a health risk	8	6	1		1					
380	Protection of natural budworm predators	8	5		1			1			1
433	Monitoring effectiveness of treatment	8	1		1			2			4
434	Pest immunity to chemical treatments	8	1	5				2			
436	Management dependence on control measure	8	3	3				2			
440	Application techniques	8	3			1		3			1
510	Western Spruce Budworm - D.E.I.S.	8	2	1				5			
535	Within USDA-USFS (coordination efforts)	8	1	1				4			2
727	Economic effects on timber industry	8	2	1	1			4			
350	Water quality/quantity protection	7	4					3			
427	Use of narrow spectrum insecticides	7	3	2	1			1			
511	Accuracy of data in the DEIS	7	1	3	1						2
123	Known effects (carbaryl on human health)	6	2	4							
165	Biological agents are carcinogenic risk	6		2	1			2	1		
250	Environmental concerns (*B.t.*)	6	5			1					
362	Completeness of data (wildlife concerns)	6		2							4
421	Short term effects known(pest mgmt.)	6	1	4				1			
513	Adequacy of data in the DEIS	6	1	3	1						1
604	Harvest practices/effects	6	3					3			
700	Socio-economic effects (general)	6	1	2				3			
125	Insecticides are a teratogenic risk	5	3			1		1			
126	Insecticides are a mutagenic risk	5	2	1		1		1			
230	Animal community (kingdom) protection	5	4					1			
317	Leaching of contaminates	5	2	2				1			
344	Stream (and river) protection	5	3					2			
418	Adequacy of analysis (pest management)	5	2	2							1
422	Long term effects known (pest mgmt.)	5	1	2				2			
441	Aerial spray application (carbaryl/*B.t.*)	5		4				1			
538	With private land owners (coordination)	5	5								
614	Naturally diverse forest	5	4								1
726	Scenic values	5	2					3			

spread. It is a native insect and only reaches outbreak proportions under certain environmental circumstances. Please refer to discussion in Chapter 4 which describes the outbreak cycle.

What are the criteria the USFS will use to determine appropriate areas to treat? Based upon these criteria, what areas are **likely** to be proposed for treatment by methods proposed in either preferred alternative?

RESPONSE: Please refer to Standards and Guidelines, Appendix C, for the criteria. The areas likely for treatment will be discussed in site specific environmental analyses.

Control areas throughout the range of infestation should be maintained to verify the effectiveness of the management program.

RESPONSE: We agree and have been installing plots in both treated and non-treated areas to determine the extent of our losses. The plots will be examined thoroughly some time after the outbreak has subsided.

The Forest Service should continue to examine alternative pesticides since new chemicals will undoubtedly be available in the future. In doing so it should, establish field tests to demonstrate the effectiveness of *B.t.* compared to carbaryl so any future EIS can be modified accordingly,___. It would not be wise to lock in long-range efforts to control the budworm to the use of *B.t.* and carbaryl only.

RESPONSE: As priorities allow and the opportunities exist, Forest Service research continues to develop appropriate pest management strategies and tactics. NEPA guidelines provide flexibility to supplement an EIS should circumstances necessitate modification.

Under, Effectiveness of Treatment Methods, page s-3, Only *B.t.* is discussed and the effectiveness of carbaryl is not mentioned. It is stated: "Treating too early can result in many individual larvae escaping exposure to *B.t.* because they are not feeding on foliage that is exposed to spray." This implies that the larvae are not feeding on the succulent and tender needles at the branch tips, where the spray is most likely to fall, but are feeding on the older needles closer to the trunk. Where do the larvae really feed? If a larvae escapes the direct spray of carbaryl will it die from ingesting the sprayed foliage?

RESPONSE: This section has been rewritten to address both carbaryl and *B.t.* Early larvae do feed on the new needles on the branch tips. However, they spin webbing around the needles so are protected from the spray deposit by the webbing. Later they become free feeding outside the webbing and are then susceptible to spray residues.

What effects does any spray, biological or chemical, have on the six instar stages or the pupae?

RESPONSE: If viable residues of either *B.t.* or carbaryl are ingested in large enough quantities, the larvae will die. The last instar is less susceptible to these insecticides than earlier stages. Insecticides are applied when most of the larvae are in the fourth and fifth stages because this is when they are freely feeding and the largest part of the population is exposed. In practice, the pupae would not be affected by *B.t.* or carbaryl sprays applied when most larvae are in the fourth or fifth instar.

Page s-4:

Alt. D has no objective listed. Why? What are nondamaging levels? Should your verbiage have read, acceptable levels of damage? Nondamage means just that.

RESPONSE: The objective for Alt. D was unintentionally omitted. Alternative D has been rewritten to incorporate the objective. We are actually referring to budworm population levels which we find to have an acceptable level of damage associated with their existence. We cannot prevent all loss; we try to minimize the losses if it is cost effective to do so.

Page s-4:

Do the capabilities exist to determine with certainty the size and intensity of past budworm outbreaks, in the Pacific northwest, over the past 100 years?

RESPONSE: No. We have aerial sketch map information on defoliation dating back to 1947. A few loss assessments done in the 60's and 70's give a suggestion as to the intensity of the outbreaks during that time. Our projections are based upon fairly small research studies.

Pages s-7 thru s-10;

Alt. B states: "Resurgence and reinvasion are not anticipated," Yet under Alt. D it is stated: "Reinvasion need not occur; resurgence may occur." Both alternatives use *B.t.* Why the difference?

RESPONSE: Resurgence can potentially occur in carbaryl treated areas when there are sublethal doses as a result of poor application. It has been shown that sublethal doses of carbamate or organophosphate insecticides can stimulate eastern spruce budworm populations. This response has not been shown with *B.t.* The difference in the alternatives is that Alternative

D provides the opportunity to use carbaryl and as such, the potential for reinvasion exists.

Pages s-7 thru s-10:

Question #7: Under Alt. B it is stated: "Earlier treatment would not have prevented the 'spread' of budworm infestation. The application of *B.t.* should have no effect on future outbreaks." Earlier than what? Is the Forest Service going to apply *B.t.* in an untimely manner? The above F.S. statement is contrary to Alt. B under Question #2; why?

RESPONSE: Treatments applied earlier in the current outbreak would not have curtailed the expansion of budworm infestation. Forest Service treatments are timely in that suppression activities are withheld during the initial phases of an outbreak. When visible defoliation is first noted, there is no way to determine how long the outbreak might persist. Please refer to discussion in Chapter 4 which describes the outbreak cycle.

Page s-13:

"Aerial insecticide application near streams and open water is controlled by state law." State law sets forth the legal aspects of insecticide application. The operator or pilot of the plane or spray rig actually controls the application of the insecticide.

RESPONSE: Thank you. This statement has been rewritten.

Page s-15:

Column two under Alt. C contains another ambiguous and confusing statement: "Reinvasion from untreated areas within the treatment areas is a potential problem." Any untreated area is outside of the treatment areas, including the so-called buffer strip along streams. Your statement should have read; 'Reinvasion from untreated areas adjacent to the treatment areas is a potential problem.

RESPONSE: Thank you. This has been rewritten.

Page s-19; Hazard Analysis:

What are the identified toxic properties of *B.t.* and other chemicals analyzed?

RESPONSE: Refer to chapter 4, Environmental Consequences and Appendix F, Human Health and Environmental Risk Assessment where the toxic properties are discussed.

Page s-20:

If the quality of data for carbaryl and *B.t.* are inadequate, how can the Forest Service consider using them?

RESPONSE: Data for carbaryl toxicity and human health is available. Available toxicity data for *B.t.* comes primarily from the history of its use. Every project undertaken implies a certain amount of risk and uncertainty. This EIS identifies those risks and uncertainties. Please review Appendix F, Human Health and Environmental Risk Assessment.

Alternatives B, C & D would rely on aerial application of insecticides. How would highway corridors be handled? Would they be treated during blanket spray applications or are they considered sensitive areas to be avoided?

RESPONSE: Treatment of these areas would be up to the responsible official. Some of these corridors may be considered sensitive areas and a resource to be protected. Site specific environmental analyses would analyze this type of question. Please refer to Appendix C, Standards and Guidelines.

The DEIS states that carbaryl "is not persistent." There was no mention of Neber's (1982) study which found carbaryl had not significantly degraded in trees during a 75 day period following spraying. The DEIS quotes Gibbs (1984) who reported residues were detectable in ponds 14 months after spraying for spruce budworm and some amphipod populations had not recovered after more than three years. Not persistent?

RESPONSE: Persistence is a relative term. We relate an insecticide's persistence to what are considered persistent insecticides, the chlorinated hydrocarbons.

Finally, the DEIS (page N-3) concludes: "Carbaryl is a broad-spectrum insecticide...as well as relatively long persistence on forest tree foliage". Relative to what? Referring to carbaryl's persistence as "relatively long" is inappropriate, even in the context given.

RESPONSE: Relative to all other available insecticides registered to suppress western spruce budworm. Of course this is an understatement. Of all of the registered materials for this purpose, carbaryl is the most persistent. The particular formulation, Sevin-4-oil is specifically made to have a longer persistence than other formulations of carbaryl. We feel the reference is appropriate.

Carbaryl is only conditionally registered by the EPA. Chronic toxicity,birth defects, and metabolism studies in dogs must be submitted and reviewed before EPA can judge what restrictions will be necessary under full registration (Mott 1986). _ _ _

3) The EPA Scientific Advisory Panel in 1980 recommended that product labels bear the warning: "Exposure to Carbaryl during pregnancy should be avoided."

RESPONSE: The teratogenic and fetotoxic potential of carbaryl is evaluated in Appendix F. The reproductive NOEL used in the risk assessment is based on a teratology study. Reproductive risks are are quantified in the risk analysis and summarized in Chapter 4. If used in any project, all label directions and precautions will be followed.

Summary, page 7 Comparison Of Alternatives. Planning Question #2, How effective are the treatment methods?

This section should point out that carbaryl is more effective in controlling **extremely high populations** of western spruce budworm than *Bacillus thuringiensis* and produces more consistent results due to a larger application window. When this is taken into consideration, the likelihood of resurgence is probably more equal between the two pesticides. Resurgence is also a potential problem with *B.t.*, albeit for a different reason. Operational use of *B.t.* and carbaryl in 1988 showed that *B.t.* continues to present a greater problem regarding the variability of treatment.

RESPONSE: We do not have good comparisons of areas of extremely high populations being treated with carbaryl and *B.t.* Nevertheless, the population level would not be expected to affect the proportion of the overall population that receives sublethal concentrations of insecticide because of poor application. We do not believe, nor have we seen evidence to this effect, that there is a practical difference in spray window between the two insecticidal materials. Any variability in *B.t.* treatment effectiveness in 1988 is likely due to application rather than insecticide used. The respondent knows that carbaryl was used in small areas where more control of operations was possible. A proper baseline for comparing carbaryl with other materials is the results from 1982 and 1983. Refer to Chapter IV for these results.

The various pesticides should be evaluated in terms of their ability to expand the "spray window". This would include evaluation of the timing of the application, insect development and foliage development.

RESPONSE: The only practical difference in a "window for effectiveness" between *B.t.* and carbaryl is that carbaryl may have some contact effectiveness in the last larval stage when they have stopped feeding. The real effects of spraying at this late stage have not been documented. One might draw the conclusion that carbaryl is more effective in suppressing extremely high populations from "inspection" of data. We know of no studies that directly compare effectiveness of carbaryl or *B.t.* where budworm population is a treatment variable. There is no data upon which you can make your inferences.

We believe that there is no real issue concerning a "window for effectiveness". We know of no instances where the results of a project would have been different if there would have been more time to spray. Increasing a "window for effectiveness" is not one of the vital issues we will pursue in future development of insecticides.

_ _ _ impact of secondary insects resulting from the low vigor of the trees which have been repeatedly defoliated by [S]pruce [B]udworm. As seen on the La Grande Ranger District, this can be a major factor in determining cost/benefits for suppression operations. This factor should be thoroughly discussed and displayed in the final EIS.

RESPONSE: The interactions between western spruce budworm and other insects and diseases is discussed in Chapter III in the section on insect and disease complex. In past outbreaks the impacts of these secondary pests have not been quantified.

The efficacy of each pesticide, under various environmental conditions should be determined. The evaluation should consider both west side and east side weather and humidity. _ _ _ .

The spray 'models' used should be calibrated for the various pesticides and the local conditions of probable use

RESPONSE: We agree. As the resources and opportunities are available, this is done.

The pesticide application for a set of conditions should be modeled on an operational basis. There is a great deal of difference spraying several hundred thousand acres as compared to several hundred.

RESPONSE: In the development of suppression tactics, the last stage is what we call a pilot project. These projects simulate operational projects.

The potential for insect tolerance and adaptation for resistance to various pesticides should be studied.

RESPONSE: We agree to the extent that this appears to be becoming a problem. Drs Robertson at PSW, Berkeley and Stock at the University of Idaho have done preliminary work using isozyme analysis.

Appendix N-2, Column 2, first paragraph.

The document states, "From the preceding it is apparent that under the conditions of these projects, there is no practical difference in the short-term population reduction efficacy of carbaryl or *B.t.*; both can reduce populations to less than 1 larva/45 cm branch tip given proper application and project administration." The 1988 federal and private projects data shows that this is not necessarily true. Early larval densities and where we are in the outbreak phase are also important in relationship to insecticide effectiveness. Check the Meacham Pilot project data; some formulations of *B.t.* did not meet the post-treatment criteria.

RESPONSE: The Meacham project was to determine if other formulations and volumes per acre were useful on an operational basis. We found that Thuricide 48LV at 43 oz./a met the criteria. What you should have seen from the discussion is that carbaryl, Sevin-4-oil, did not meet our current criteria of reducing larval populations to an average of less than 1 larva per 45 cm branch tip on many areas when it was used operationally in 1982 and 1983.

Resurgence

Chapter IV - 8, 9, & 10; and Summary - 7 - 10 (Comparison of Alternatives)

The discussions throughout on resurgence of budworm populations after treatments is strongly biased in favor of *B.t.*. Why? Where is the data after almost a decade of treatments? The potential for resurgence and reinvasion, based upon our experiences in Oregon over the past six years, appear to be more of a problem in the early years of the outbreak. The key factor is pre- and post- spray larval populations with each respective insecticide. The statement that resurgence is not expected to be a problem with *B.t.* because sublethal doses do not stimulate vigorous populations is unproven, and in our opinion, untrue. If *B.t.* or any insecticide, does not kill significant numbers of larvae, populations will likely resurge.

RESPONSE: We do not believe that the information is biased in favor of *B.t.* We have looked at all available information pertinent to the subject and have presented it. As you know there really is no data specific to the subject. We then have to look at whatever is available on related subjects. As an example, we refer to the paper by Smirnoff relating to population stimulation by sublethal doses of carbamates. We do not know what the probability of this happening with poor spray applications of Sevin-4-oil against western spruce budworm. We do feel it would be irresponsible at least to not acknowledge that there is a potential of this occurring, albeit unquantified. We have no similar information on *B.t.* causing this phenomenon so cannot comment on it. We agree with your statement "If *B.t.* or any insecticide, does not kill significant numbers of larvae, populations will likely resurge." Our only difference is that it may be possible with carbaryl that the populations may be more vigorous than with *B.t.*

CURRENT PROPOSAL

Alternatives B, C and D predict a need for two treatments on recently infested units to effect adequate protection until the outbreak collapses (DEIS, page II-3). This projection seems to be based on the unjustified, undocumented assumption that: (1) resurgence will take place; and (2) the population collapses, regardless of treatment, in exactly 10 years. Neither have been satisfactorily documented for carbaryl.

RESPONSE: These are assumptions, nothing more. We do not have documentation with carbaryl or *B.t.* We feel it is responsible to be somewhat conservative when selecting areas for treatment. Areas remaining a good investment under these assumptions are probably better investments than those not.

We contend that the USFS is attempting to divert the attention from the beneficial aspects of carbaryl by stating: "The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of vigorous populations" (DEIS, page II-6, #7, Alt D). Why would you recommend using sublethal dosages?

RESPONSE: We don't use sublethal doses. We know that in operational projects the treatment areas are not treated uniformly resulting in some areas having skips and areas of sublethal deposition.

We find it terribly misleading, and contrary to facts presented in the DEIS, to read that carbaryl "may produce significant impacts to some resources" (DEIS, page II-4, #3, Alt. C). Documentation fails to

justify "significant impacts" except on insects. We find the difference between this statement and that of Alt. D to be highly prejudicial and inappropriate.

RESPONSE: Please refer to the wildlife and aquatics discussions in Chapter IV. These impacts can be mitigated to an extent. There is a further discussion of these potential effects in Appendix F.

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12. A statistically documentable analysis of the efficacy of *B.t.* should be presented in the Final EIS.

RESPONSE: We have no new information to add to that found in the Draft EIS. The information available on both carbaryl and *B.t.* is similar.

The summary on page 5 mentions the role of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This should be expanded to make it clear that any application of pesticides will conform to the application rates allowed and restrictions on the label.

RESPONSE: Our policy is to conform to label restrictions.

In 1987, 60,000 acres were improperly prescribed for spruce budworm spraying. Apparently, the sites did not even contain host species for the budworm. Forest Service has not indicated how such poor judgment will be avoided in the future.

RESPONSE: This is a reference to acres included in a larger analysis unit. A closer look was taken after the units were found to be economically feasible to treat. At this point further work was done to refine the actual proposed treatment area. We do not see this as poor judgement but probably a difference in the sequence in which various tasks are done.

The EIS refers to a 1986 study by Jeffrey Miller in Oregon following the use of *B.t.* in the state's gypsy moth project.

As it turns out, no citation is given in the EIS for the "Miller 1986" reference, but attached is a 1988 article by Jeffrey Miller (Attachment D) which contains conclusions directly contradictory to those "cited" by the EIS.

RESPONSE: The citation is Miller, Jeffrey C. 1986. Impact of *B.t.* applications for the control of gypsy moth in Oregon: Affects on nontarget Lepidoptera. Oregon Department of Agriculture. Final Rep. 6 p. The reference is correct and not contradictory as it relates to numbers of lepidoptera larvae. Miller in his 1988 paper, Table 1, shows the same result. The additional information presented in the 1988 paper refers to species richness, numbers of species of lepidoptera. He found that "Although the 1988 species count nearly equaled that of the 1986 prespray sample, the number of species was significantly lower relative to the 1988 untreated plots. These data indicated populations of Lepidoptera were recuperating but the negative impact on spring species extended over a period of at least 760 days." We agree with Miller's interpretation of his data. We also agree with the importance of the impacts of eradication programs on biological control organisms, bird reproduction and possible extinction of endangered lepidoptera. We do not have information to suggest that a single application of *B.t.* once or twice during a period of 6 to 10 years poses a great risk.

The indiscriminate killing of invertebrates by carbaryl and the attack on all Lepidoptera larvae exposed to the *B.t.* spray imply that the proposed massive spray program has potentially severe, indirect, and long lasting effects on forest community structure, species, and food networks. These effects have not been examined by the EIS.

RESPONSE: We have no information which indicates that what you suggest is a problem. Until we have reliable information that this "global" sort of consequence is remotely possible we must concentrate on areas where we can make a difference in conducting these analyses and projects.

Spray programs appear to be a band-aid for ecologically unsound forest management. The DEIS should delineate those specific situations where the use of specific chemicals, as opposed to some other management approach, is the best way to achieve healthy watersheds. Broad statements permitting the use of *B.t.* and/or carbaryl at the discretion of the local land manager amounts to issuance of a "spraying license," not implementation of a pest management program.

RESPONSE: Specific requirements which must be met before any spray program would be undertaken are in Appendix C, Standards and Guidelines. All site-specific Environmental Assessments will be tiered to this EIS.

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(8) The full range of alternatives for spruce budworm control was briefly mentioned, but not really considered. The range considered should have included a more toxic, more effective method of control. By deleting the more toxic alternatives outside of the EIS documentation, the public is mislead to believe that the carbaryl alternative is actually the extreme worst alternative available.

RESPONSE: Refer to Chapter 2, Alternatives considered by eliminated from detailed study.

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2) A preferred alternative should be developed which is based upon the effectiveness of the control methods or agents to suppress, or preferably eradicate, the target pest without undue risk to the public's health or unacceptable damage to the environment.

RESPONSE: Please refer to Chapter II, Alternatives. Our objective is not to eradicate western spruce budworm, but to suppression the populations to nondamaging levels.

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6) A preferred plan would be to modify Alternative D to include the use of *B.t.* in conjunction with any or all registered insecticides, including but not limited to carbaryl. Once it has been determined which of the products (with mitigation measures) do not pose an unreasonable risk, the various insecticide products should then be prioritized according to potential impacts on the environment, efficacy and cost.

RESPONSE: Please refer to Chapter II, Alternatives. Chemical insecticides besides carbaryl were considered but eliminated from detailed study because they are considered non-efficacious in suppressing western spruce budworm.

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7) The Forest Service should undertake scientific and controlled tests under actual conditions (i.e. test plots) to determine the most effective combination of control products to use. Particular attention should be given to study the effect of combining two or more insecticides as a means of retarding the development of resistance by the budworm. This method has been proven effective in other insect control areas, such as mites.

RESPONSE: As resources and opportunities exist our scientists continue to develop strategies and tactics in pest management technology.

Silviculture

Stocking control of these stands is really a key issue. Money needs to be allocated to allow for reducing the stocking in those stands that could respond to such treatment. In those stands that are 'too far gone' to respond to some type of thinning or stocking control, we should consider final harvest or stand destruction and replacement with a new, vigorous plantation of acceptable species.

...Furthermore all future harvesting of trees should be through selective cutting designed to maintain a sound balance of species and age groups.

RESPONSE: Silvicultural prescriptions for harvest methods are outside of the scope of this document. Silviculture treatments will be prescribed on a stand by stand basis within the constraints of the Forest Plans.

The mortality and top-kill figures depicted on page G-6 (DEIS) should be examined and updated, particularly for site-specific economic analysis.

RESPONSE: The mortality and top-kill figures are based upon the current available data. These figures are updated periodically as new data becomes available.

Although infestation may lead to delays in silvicultural treatments, when the outbreak is controlled, practices should be intensified to improve stand quality and recapture both value and growth.

RESPONSE: This is outside of the scope of this document. Silvicultural treatments to improve quality will be prescribed on a stand by stand basis under the guidelines of the Forest Plans.

The scope of the DEIS is too narrowly defined...

...Integrated Pest Management strategies are not discussed.

RESPONSE: We agree that suppression of the current western spruce budworm epidemic will not resolve potential future outbreaks. Management strategies considered in this EIS do provide protection for valuable resources until silvicultural treatments can be integrated into the forest planning process.

The EIS needs to better clarify the biological and economic significance of timber growth loss...

...I feel the net loss of 933 board feet per acre is significantly low, and the cumulative impact of this loss has not been adequately documented.

...The DEIS needs to separate what, if any, growth loss is attributable solely to the spruce budworm from growth reductions due to factors (such as weather) that hinder average annual growth.

RESPONSE: The growth loss calculated in the site-specific EA (referenced in appendix G of the DEIS) is only that attributed to the spruce budworm.

Neither preferred alternative addresses the fact that stands are predisposed to spruce budworm damage.

RESPONSE: Chapter III, the effected environment, discusses predisposition of some stands to spruce budworm attack. The Alternatives discuss methods of suppression this outbreak. Stand manipulation techniques are outside the scope of this document. Silvicultural treatments would not apply to the current outbreak.

The document notes that in both preferred alternatives "[c]urrent practices in the infested areas would continue." and that "[s]ilvicultural prescriptions may be changed to respond to damage to forest stands." What constitutes "current practices" and how silvicultural prescriptions might be modified is unclear. Will this require greater reliance upon even-aged methods, or will uneven-aged methods be applied as is being considered for inclusion in some Forest Plans?

RESPONSE: The term 'current practices' is referring to silvicultural practices that are used on Forests at this time, or that will come into effect with the implementation of the Forest Plans. Prescriptions written for stands that sustain subsequent amounts of damage, may of necessity be changed. These prescriptions are implemented on a stand-by-stand basis at the local level.

How will selection of any one of these alternatives affect proposed harvest levels published in Draft Forest Plans, or in future Final Forest Plans? Did Forest Plans account for the effects of epidemic vs endemic spruce budworm in their volume projections?

RESPONSE: Forest planning has not yet reached a stage where potential insect and disease epidemics are reflected in volume projections. The modeling process is rapidly moving toward this planning goal.

The DEIS's attempt to address the long term issue is inadequate, specifically because the commitment (I-3) lacks substance and concrete planning

...A long-term goal of using silvicultural manipulation should be considered a viable alternative. It may not meet the immediate goal of budworm outbreak eradication, but I feel that the alternative displayed in the DEIS do not meet this immediate goal.

...The final EIS could remedy this deficiency in part by:

-providing specific links and guidance to individual Forest Plans which address both short and long term measures --- and the next planning cycle is too long to wait.

RESPONSE: Both direct suppression and long term silvicultural manipulation are components of Integrated Pest Management. This document reflects only the direct suppression of this outbreak. The scope of this document, of necessity, has been limited to treatment options that are viable for this outbreak cycle.

Page s-13:

Alternatives B,C and D is stated: "With the action alternatives, there would be very little budworm-caused mortality in the undamaged stands." Is this a staff consensus or an actual field observation?

RESPONSE: It is an Interdisciplinary Team consensus based upon a review of the available data and historical field observations.

Page s-15:

Second paragraph, left column. What will bring about the proliferation of extensive areas of the preferred hosts?

RESPONSE: Increases of stands of the preferred host species is discussed in Chapter III, Vegetation.

Summary, page 5, USDA Forest Service Management Objectives, B. **Oregon and Washington State Forest Practices Act.**

...mentions only Oregon, what about Washington?

RESPONSE: The Washington Forest Practices Act is discussed in Chapter I of the DEIS. This discussion was inadvertently left out of the Summary.

Chapter IV, page 9, Environmental Consequences, Background, Regional Environmental Effects, par. 1.

The western spruce budworm outbreak has not spread across the Cascades into west-side forests in Washington.

RESPONSE: The outbreak has just recently spread across the Cascades into west-side forests in Oregon.

Objectives dealing with timber supply, and effectiveness of each alternative needs to be added.

RESPONSE: Effectiveness of Alternatives in suppression of budworm populations is discussed in Chapter IV, Insect Complex.

Chapter IV -5, Columns 1 & 2.

There is no mention of how the severity of budworm impacts differ with uneven and even age stand management.

...Uneven-aged management will perpetuate stand conditions that are favorable to the development and spread of spruce budworm. How is the deliberate creation of defoliator habitat reconciled with the preferred suppression strategies proposed in this management plan?

RESPONSE: Uneven aged management is being addressed in the Final Land and Resource Management Plans. Public response to this issue has been strong and the Final Plans will reflect considerations of this issue.

Chapter IV - 5, Column 2, paragraph 6.

Chapter IV - 6, Column 1, paragraph 1.

The ability of non-host conifers to make-up growth losses in host conifers is over emphasized. Most severely impacted stands do not have a significant non-host component. This is particularly the case in the Cascades and parts of northeast Oregon. It is also untrue that host trees will be replaced over time by more resistant species. If stands receive uneven age management and fire exclusion, stand composition will remain much the same.

RESPONSE: Growth losses can be compensated to an extent by increased growth of non-host species in mixed species stands. Host trees can also be replaced in mixed species stands. Stand compositions vary across the Region and no one description will fit all stand types. The document attempts to discuss many potential scenarios.

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(3) Timber (Managed Stands) (page IV-5) - This section fails to evaluate the potential for losses due to secondary insects and disease. Evidence in Northeast Oregon indicates that losses from these secondary sources may be substantial.

RESPONSE: The interactions between western spruce budworm and other insects and diseases is discussed in Chapter III, in the section on the Insect and Disease Complex. In past outbreaks the impacts of these secondary pests have not been quantified.

Human Health

...Carbaryl is acutely toxic and has been shown to cause chronic effects including carcinogenic, teratogenic, and mutagenic effects.

...DEIS Summary p. 10 states "Carbaryl poses a human health risk only in the case of accidents." The five year ban on carbaryl use in the Carson National Forest (inclusion "B") brought up more serious questions of health risks. Inclusions "C" through "G" attest to carbaryl's health risks, especially its' teratogenic risks which were not even mentioned in "Carbaryl's Risk Assessment Results" DEIS Summary pp 19-20.

RESPONSE: A discussion of Human Health issues is included in Chapter IV, Human Health, and Appendix F, Human Health and Environmental Risk Assessment for the Use of Insecticides.

Alternative B *Bacillus Thuringiensis use should not be used because not enough is known about the far reaching aftereffects of its use. What about reproductive and carcinogenic potentials?

RESPONSE: Although no data is available concerning the carcinogenic potential of *B.t.*, margins of safety for general systemic and reproductive effects have been calculated. This discussion is located in Chapter IV, Human Health.

The effect on human health seems to be limited in information--whether carcinogenic or having skin effects when there are gastro-intestinal and respiratory effects on humans and wildlife.

RESPONSE: Please review Chapter IV and Appendix F (Human Health and Environmental Risk Assessment) in the FEIS. They have both undergone some change since the DEIS was released. In addition, incomplete or unavailable information is discussed in Chapt. IV and Appendix F.

Pages s-7 thru s-10:

Question #8. Under Alt. C it is stated: "Carbaryl poses a human health risk only in the case of accidents." First, the DEIS summary does not list the component of carbaryl, both active and inactive including carriers. Second, unless so specified, when speaking of carbaryl it includes all components that would be sprayed for budworm control.

RESPONSE: The summary only provides a summarization of the EIS. A complete discussion is located in Chapter IV of the FEIS and in Appendix F.

Pages s-7 thru s-10:

On pages s-21 it is stated: "Unprotected workers who routinely apply carbaryl may experience some toxic effects from the kerosene-diesel oil mixture." What is the true risk from CARBARYL? Under Alt. D, what is a "human health risk of an intermediate nature? How is it measured?

RESPONSE: The phrase "human health risk of an intermediate nature" has been rewritten to portray a level of risk less than Alternative C, but greater than Alternative B. The level of risk associated with this alternative is not readily measurable, however the degree of risk is relatively proportionate to the amounts of *B.t.* and carbaryl used. The full discussion of human health risks is located in Chapter IV and Appendix F.

Page s-13:

Under Public Health, what hard evidence does the F.S. have that those people living near forest lands are any more concerned with environmental issues than those living elsewhere?

RESPONSE: We did not state nor did we mean to infer that people living near forest lands are more concerned with environmental issues than people living elsewhere. During the scoping process and public response to the DEIS, we received many comments from people living near Forest Service administered lands as well as those living in more urban areas. A more complete discussion of this subject can be found in Chapter IV--15 under "Lifestyles, Attitudes, Beliefs and Values".

Page s-19; Risk Analysis:

What is the NOEL level in PPM that would equal a MB of 100?

RESPONSE: To achieve a MOS of 100, the estimated exposure received must be 1/100th of the NOEL, which is the dose of a particular chemical demonstrated to have shown no adverse effects to laboratory animals. The NOEL varies with the compound that is being evaluated and the toxic endpoint being evaluated (e.g. systemic vs. reproductive effects). The exposure depends on many variables, including length of time exposed, amount of chemical to which exposed, and route of exposure under consideration (e.g, eating contaminated food vs. spilling herbicide on one's skin). Please refer to Appendix F for a detailed discussion of how the risk calculations were carried out.

Page s-19; Carbaryl:

What is considered as: "the absence of significant tumor incidence.?" Who has to have the tumor for it to be significant, you, me or the rat?

RESPONSE: In this context, "significant" refers to statistical significance. A certain background incidence of tumors is found in laboratory animals that have not been knowingly exposed to any known oncogenic substances. In order to make a determination that a test substance results in tumor formation, there must be a statistically significant increase in tumor incidence in the animals dosed with the compound as compared to the number of tumors observed in the control group animals that were not dosed.

Page s-21;

Risk to the Public in Accidents. Are these risks for carbaryl only or for all sprays?

RESPONSE: This discussion refers to all sprays.

Carbaryl has been found to depress the immune response in rabbits (Street & Shurma 1975) and to increase the susceptibility of human cells to viral growth (Abrahamsen & Jerkofsky 1981). These studies were not cited in the DEIS. Concern over the viral enhancement effects of carbaryl led a panel of physicians formed by the Maine State Department of Agriculture to recommend that state allow no uninformed or unconsented human exposure.

RESPONSE: Although these studies suggest there may be a potential for low level immunotoxic effects, there are not sufficient data to support a quantitative evaluation of this risk.

The DEIS is simply wrong when stating "petroleum distillates are listed by EPA as insert ingredients of no toxicological concern." Quoting EPA, "The Environmental Protection Agency is concerned about petroleum distillates which occur in about 80% of all pesticide formulations as inerts or actives and pose significant regulatory problems...the polynuclear aromatic hydrocarbons of petroleum distillates have a high potential for carcinogenicity and the alliphatic content may post problems as well" (EPA 1984z, EPA 1984b, EPA 1984c). In light of the above quotation, the DEIA misleads the public when stating, "The majority of studies examining the carcinogenic potential (of carbaryl) have been negative."

RESPONSE: The description of EPA's classification of petroleum hydro- carbons has been corrected, as they are on EPA's List 2, meaning they are potentially

toxic inerts with a high priority for testing. In reference to the carcinogenicity studies on carbaryl, however, the DEIS is correct, because chronic toxicity tests are usually only conducted on the active ingredient, in this case, carbaryl. That is why the toxicity of inerts in the formulated products (kerosene) and carriers recommended for use (diesel oil) are evaluated separately.

We strongly object, however, to the suggestion in chapter IV, 38 (and repeated in Appendix F) that the effects are likely to be contact dermatitis only, serious as that could be. In our case, exposures of the type contemplated in the DEIS would in all likelihood induce far more serious reactions, including very possibly seizures and immunosuppression. This DEIS suggests that it covers all likely problems, except for statistically rare individuals who would get rashes; in that area it is seriously inaccurate and inadequate.

RESPONSE: According to results of the risk analysis, estimated levels of exposure to the public are low. At these levels mild symptoms are possible in sensitive individuals, however serious reactions are unlikely. The EIS discusses the variation in sensitivity found in the human population (in the "Effects on Sensitive Individuals" section of Chapt. IV), and acknowledges, unusually sensitive people may experience effects even when the margin of safety is equal to or greater than 100.

In the NIOSH study of B.t. application in Lane County Oregon (report attached), the biological insecticide was found to be a safe and effective means for managing insect infestations. In that study, however, it was recommended that agencies considering large scale B.t. application pay specific consideration to those situations where a small percentage of individuals (residents or workers) may experience adverse health effects because of individual susceptibility to biological insecticides. In the forthcoming project, therefore, it is strongly recommended that the Forest Service implement a surveillance program which would identify and follow immuno-suppressed or hypersensitive individuals in the application area who may be at risk. Every effort should be made to fully advise the general public as to the time and area where B.t. is to be applied.

RESPONSE: A public information plan will be initiated prior to commencement of any spray project. This is discussed in Appendix C, Standards and Guidelines.

At actual field sites, it is not reasonable to expect application workers to make a consistently correct selection and use of protective equipment under physically stressful field conditions. The Final Environmental Impact Statement (FEIS) should include more details of proposed management/supervisory practices which are planned to insure compliance with the proper selection and use of personal protective equipment in the field.

RESPONSE: As prescribed in Appendix C (Standards and Guidelines), site specific environmental assessments which prescribe direct suppression measures will require a written project plan before before treatment projects may proceed. Concerns for applicator/employee safety would certainly be an integral part of this plan. Operational procedures as they pertain to personal safety would be detailed in this site specific plan.

Residues from B.t. or carbaryl on crops could be a concern. If substantial overspray or spray drift into crop areas could occur during pesticide application, the Forest Service should develop techniques to investigate if any substantial settling on crops has occurred in order to reduce and/or eliminate residues which might enter the human food chain.

RESPONSE: Appendix C (Standards and Guidelines) provides for the preparation of a site specific project plan prior to implementation of direct suppression projects. Guidelines for spray operations and monitoring are key components of this plan.

Page II-7, #8, Alt C refers to carbaryl as the "highest risk to human health", when it more appropriately should read "presents a greater, but still minimal, risk to human health".

RESPONSE: Portions of the section to which you refer (Comparison of Alternatives) have been rewritten to more clearly depict the comparison which is being made. This statement has been rewritten to clarify that Alternative C represents the highest risk to human health of the alternatives being considered.

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13. **The DEIS must discuss how children are placed at greater risk from exposure to toxics (including insecticides).**

RESPONSE: An analysis of risk to children has been completed and has been integrated into Appendix F.

The definition of inert given in the Glossary is dangerously false and the discussion of List 3 inert on p. 130 of Appendix F is totally misleading: "...neither available toxicity data nor a review of their chemical structure shows evidence that would place them in Lists 1 or 2". In fact, List 3 inerts are secret ingredients for which no toxicology data are available.

RESPONSE: The definition of inert ingredients in the Glossary has been revised in response to your comment. In the formulation of its' lists of inert ingredients, according to EPA's Office of Public Affairs "Environmental News" publication of April 21, 1987, EPA first identified approximately 1,200 inert ingredients used in pesticide formulations. They then reviewed the data available on each of these compounds. Approximately 50 were identified as being of significant toxicological concern, another 50 or so are believed to be potentially toxic and should be assessed for effects of concern, and approximately 300 are generally regarded as minimally hazardous to humans and the environment. The remaining inerts are referred to as List 3, and are compounds for which there was no basis for inclusion in the lists. It does not mean that there was no information available on them.

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1. The EIS bases its analysis of carbaryl risk to humans on an estimated 10% dermal penetration (Appendix F, p.81), citing the 1985 USDA EIS for gypsy moth eradication as the reference. In fact, the only peer-reviewed, published study of human skin absorption of carbaryl indicates that 73.9% of carbaryl is absorbed by the forearm and the forearm is one of the least permeable areas on the body (See Attachment G).

RESPONSE: The risk assessment has been revised, incorporating the use of the dermal penetration rate for carbaryl of 73.9% into the exposure calculations, based on the 1974 study by Feldmann and Maibach.

To salvage the mortality would require covering the entire forest every two or three years! This would create a drastic change in timber quality, volume per acre and logging costs, which would have spinoff impacts on community stability and overall forest conditions. ...While this is a good idea, the USFS has not thoroughly thought out the impacts of such measures.

...What are the economic impacts of such a change in the harvest mix, volume per acre and quality?

RESPONSE: Any salvage of budworm mortality would be considered on a case by case basis in a site-specific Environmental Analysis. We did not mean to imply that all mortality would be salvaged.

P. Summary--5. Under USDA goals, I would prefer changing **adequate** to an **abundant** supply. . .,but check USDA regulations to see how they state this.

RESPONSE: The USDA goal referred to uses the word "adequate" to describe the level of supply. The wording of this goal is not subject to change in this document.

Growth Loss

Chapter IV - 5, Column 2, paragraph 4.

The impact section does not cite the following pertinent publication:

Alfaro, Rene I. 1986. "Mortality and Top-Kill in Douglas-fir Following Defoliation by the Western Spruce Budworm in British Columbia". J. Entomol. Soc. Brit., Columbia 83, Dec. 31, 1986.

RESPONSE: This publication has been reviewed and is cited in the discussion addressing top-kill in CHAPT. IV.

Water

An evaluation and discussion of the potential for ground-water contamination from spraying is needed. Carbaryl is among the list of priority pesticides listed by EPA as having a high potential for leaching into ground-water.

Carbaryl was detected at up to 60 ppb in underlying ground water within two months and persisted through the eighth month.

Carbaryl has been shown to persist in soils up to eight months and leach into ground water.

The FEIS should examine the potential areas to be sprayed that are recharge zones for private and public ground water supplies.

RESPONSE: The vast majority of fate studies on carbaryl conclude that it is nonpersistent in soil and water, with half-lives less than one month in either medium. The discussion of carbaryl's potential to contaminate groundwater has been expanded. Local potential for groundwater contamination will be addressed in site-specific analyses.

I have heard stories myself about accidents that do happen with application of chemicals and polluting streams. _ _ _ I feel it (carbaryl) is unsafe to use even with a buffer of B.t. as the rain would wash the residues into our water.

RESPONSE: Runoff of carbaryl was evaluated in Appendix F, section 3. The model allowed for estimation of insecticide concentrations in the runoff and in a downstream reservoir. Several worst case assumptions were made in these calculations. For example, it was assumed that within one watershed 5,000 acres per day were treated on three consecutive days, followed by a large rainfall on the fourth day. Risks are calculated in section 4 of Appendix f and summarized in Chapter IV of the EIS.

The DEIS states that "[I]sect (management) activities have the potential to effect fish habitat characteristics such as water temperature; sediment load; turbidity; water quantity; timing of flows; and the character of streamside vegetation. It also states that "significant increases in annual streamflow could result from the cumulative impacts of a severe budworm defoliation and management activities" (summary, p 13). The DEIS should describe, in detail, how land managers will insure that these cumulative effects will not occur.

RESPONSE: Some fisheries habitat characteristics such as stream flow, can be affected by severe defoliation and tree mortality. However, it is more likely that these impacts would result from salvage operations and associated road construction, as opposed to defoliation. These activities would be guided by individual Forest Plans and site specific environmental assessments. Best Management Practices (BMP's) would be utilized to minimize impacts. Cumulative effects would be evaluated under the Forest Plan. The reference to "Significant increases in annual streamflow......" has been rewritten to read, "Statistically significant increases in streamflow could result from the cumulative impacts of a severe budworm defoliation and management activities." If the stream is in good condition and (BMP's) are utilized, any increase in flow should be temporary and should not have a substantial effect on fisheries habitat.

What stream classification would be used when determining acceptable drainage channels that could be sprayed?

RESPONSE: The USDA Forest Service stream classification system (Appendix J) will be the primary system utilized in the differentiation of stream channels. Appendix C (Protection of Water-related Resources) provides a description of applicable mitigation measures.

Carbaryl is harmful to many important aquatic invertebrates even in very small concentrations.

Even though Carbaryl will not kill the resident fish at application levels, amounts in the water as low as 5ug/l (5 parts per billion) can disrupt and destroy the invertebrate food base for these animals.

RESPONSE: The concentrations in water bodies were calculated using very conservative assumptions (See response to # A4). These concentrations will be transient in running water such as streams and rivers, while the risks were calculated based on 96-hour toxicity values (LC 50 's). Risks to individual organisms are present, but risks to entire aquatic communities are expected to be low.

Very little research has been carried out in testing this [B.t.] agent on stream animals. The Forest Service should take the lead in demonstrating to the public that this control method is safe to non-target organisms.

RESPONSE: Wildlife and aquatic species are not at risk from *B.t.* applications. Additional discussion concerning this point is located in Chapter IV and Appendix F.

Page s-15 & s-16:

Does carbaryl bind to soil particles? If not, could rain after spraying move carbaryl into streams through the soil in much less than 5 days?

Also it is stated: "Carbaryl degrades rapidly in water in 1 to 5 days." What does carbaryl degrade into, elements etc? Does it actually degrade or does it just become diluted? Would not carbaryl's low solubility factor hinder it's degrading, in water, if in fact it degrades?

RESPONSE: The vast majority of fate studies on carbaryl conclude that it is nonpersistent in soil and water, with half-lives of less than one month in either medium. Further discussion of this subject is located in Chapter IV, as well as in Appendix F (section 3) and Attachment F-A.

Page s-20;

Margins of Safety for Special Case analysis. "....so there is little risk from runoff when large areas of a watershed are sprayed,..." Sprayed with what?

RESPONSE: This section of the summary is discussing the potential effects of the use of *B.t.* Format changes in the FEIS should clarify this.

Due to carbaryl, "there may be a 50-100% reduction in aquatic insect populations in treated streams and ponds" (Burdick et. al 1960).

RESPONSE: According to the study cited, direct spraying of streams at 1.25 lb/acre produced this effect. The Forest Service will not be direct spraying streams and ponds. Refer to (Protection of Water-related Resources) Appendix C for a description of applicable mitigation measures.

When referring to prespray and postspray fish abundance, the DEIS (page H-3) notes that increases ranged from 7 to 19 percent. It continues, however, noting that CPUE increased 115 percent at Site 7F and 91 percent on the control stream. What is the derivation of these numbers? Is it correct?

RESPONSE: *> ID <*

Although Weyerhaeuser supports maintaining a buffer adjacent to water where no carbaryl would be applied, it is worth noting that, "no significant adverse effects are expected from direct spraying of a pond at worst case rates for carbaryl" (Q--6).

RESPONSE: To improve readability of the document Appendix Q has not been included in the FEIS. The material from this appendix, including the reference to which you refer has been incorporated into Chapter IV of the FEIS.

A one-swath untreated buffer strip...is highly ambiguous.

A swath of only 60 feet (AOR 629-24-203), spraying carbaryl in steep, highly dissected terrain could easily result in drift and soil throughflow to streams if not outright direct deposition on small undetected first-order streams.

Forest Service should identify a size for its own buffer zone that it considers adequate to protect aquatic resources and water. Reliance on state buffers is clearly inadequate.

RESPONSE: A one-swath untreated buffer strip is the minimum buffer which would be retained adjacent to streams or areas of open water. The States of Oregon and Washington require buffer strips of at least 60 and 50 feet respectively during the aerial application of forest chemicals. One swath width for most methods of aerial application would far exceed the state minimums. Buffer width is dependent upon numerous site specific variables. The determination of buffer width is dependent upon consideration of topographic features such as slope, aspect, ridges, and other landforms. Depending on the type of formulation being applied, weather parameters such as wind speed and direction, turbulence, air temperature, relative humidity, temperature inversions and moisture are important considerations which affect spray drift. The type of aircraft as well as the hardware used to spray specific formulations are considered in allowances for drift. Consideration and modeling of these variables is necessary on a site specific basis. As such, the exact determination of buffer width will be made on a project by project basis. Appendix C presents a further discussion of these variables and their influence on spray drift.

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(2) Water Quality/Quantity (page IV-2) - This seems to be deficient in addressing the impacts on water quality. Although the discussion may be fragmented throughout the document, it should be pulled together into a cohesive and comprehensive discussion under this heading.

RESPONSE: This section has been re-edited and expanded to include a discussion of impacts to ground water.

Economics

The document fails to disclose the likely effects (in terms of future endemic and epidemic populations and the resulting economic and growth opportunity costs) associated with proposed Forest Service silvicultural practices.

RESPONSE: Effects of proposed Forest Service silvicultural practices are outside the scope of this document. This EIS addresses treatment methodology for the current outbreak only.

Treatment cost are predicted upon the assumption of one of at most two treatments....what is the expected cost of subsequent treatments should the current epidemic resurge...The expected cost of subsequent treatments should be considered in the economic analysis.

RESPONSE: Analysis unit treatment costs include the expected cost of a second treatment, which varies with proportion of acres in early stages of infestation (APPENDIX E--3, **Treatment and Protection Costs**).

Economic impacts must be assessed on the entire stand over periods of time longer than the outbreak period.

RESPONSE: Cost-benefit impacts on stands are evaluated through final harvest or over the time period for which the Stand Prognosis Growth Model is used to project biological impacts on fiber production (See Appendix G--1. Depending on the time remaining in the current stand rotation, for most stands these effects extend far beyond the outbreak period.

Precautions and monitoring increase treatment costs and reduce efficacy.

RESPONSE: The monitoring would be more intensive for carbaryl than B.t. However, considering the total cost for procurement, application, and monitoring for both B.t. and Carbaryl, cost are expected to be similar. Because these individual costs are included in the estimate of total treatment costs, any future real differences in cost for these or other reasons will be reflected in total costs (See Appendix E, **Treatment Costs**).

Nowhere in the DEIS is there a meaningful discussion of the aggregate effect upon local and regional harvest levels that would result from selection of any one of the four proposed alternatives. Given that the ultimate reason for managing the forest for wood products is its beneficial effect upon the human environment, this seems to be a serious omission. How is it possible to estimate economic effects resulting from any of the alternatives, let alone make a rational selection from among them in the absence of this information?

RESPONSE: An analysis of aggregate harvest impacts by proposed alternative will be presented in the site-specific environmental assessment (EA) document for specific geographic areas identified by the EA. As noted in Appendix E, **Reporting the Results**, for each analysis unit is made an estimate of harvest volume that could be gained by treatment.

Nowhere in the document is the quantitative information displayed that would indicate the analysis was actually conducted. I am left with the impression that there was an analysis plan prepared, but that somehow the required analysis was never complete. ...While Appendix G presents a detailed discussion of the methodology used in the analysis, it provides very little information regarding the actual results.

RESPONSE: An economic analysis will be conducted annually during the course of an outbreak for analysis units identified by a site-specific EA document. Results will be presented in that document as described in Appendix E.

Page s-13:

Social and Economic Conditions. If the first sentence of this topic is true, why are so many people from outside of the area so concerned? Do not the forest outputs in Oregon and Washington, which are affected by the spruce budworm, directly influence the possibility of the millions of first time home buyers of having a unit available?

RESPONSE: The most direct and measurable impacts of budworm fall upon people and communities in the States of Washington and Oregon. Some impacts occur outside the Pacific Northwest. These are small by comparison, very widely dispersed, and difficult to measure. Efficiency effects are quantified for the nation as a whole and reported in the site-specific EA.

A secondary goal should be to prevent or reduce the loss of economic value of forests and the future supply of timber where a truly valuable asset is at serious risk. Growth loss alone should not be a sufficient reason to justify an active control program. ...Regional guidelines should be formulated to provide clear and specific criteria which must be met to justify a particular treatment project. These should be included in the Final EIS along with an explanation of their economic and environmental consequences. They should include threshold values of PNV gain and for Benefit/Cost ration.

RESPONSE: Present net value (PNV) or benefit-cost is just one of several criteria in determining the merit and extent of a control program. Threshold values are not established because they limit the decision-maker's flexibility to weigh trade-offs between conflicting economic and non-economic criteria.

The costs of a "no action" alternative should be evaluated. This would include such items as slashing, piling, burning and reforestation as well as the lost opportunity costs of the infected stands, in terms of ASQ, wildlife habitat, water quality, and aesthetics.

RESPONSE: If identified as an issue or concern in the EA scoping process and if the effects as mentioned can be identified, measured, valued and mitigated or averted by a protection alternative, they enter directly into the economic analysis as costs averted, i.e., benefits ascribed to the protection alternative (Appendix D--2, **Calculating Nontimber Economic Effects**). Noneconomic or incommensurable effects are dealt with as noted in Appendix C--5,

Noneconomic And Incommensurable Considerations.

Importance of stable funding should be discussed.

RESPONSE: Annual fluctuation in funding is one of several uncertainties considered when submitting multi-year funding requests and establishing treatment priorities.

The importance of the timber resource to the local communities in terms of economic stability should be considered in the economic analysis. ...The DEIS should provide in tabular and graphic form quantitative estimates of **projected** volume production, employment (direct and indirect), receipts to counties, and local service levels for both local and regional economies.

RESPONSE: Budworm caused timber resource impacts tend to be distributed uniformly over large geographic areas and long time horizons. Chapter IV--40, **Economic Efficiency and Local Impact** discusses potential short-term local impacts. Projected volumes at risk are provided in a site specific EA. When identified as an issue or concern by the site specific EA, impacts on employment, country receipts and local services will handle in the manner described in Appendix D--2, **Local Economic Impacts**.

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10. **Economic costs need to be specifically identified.**

The DEIS fails to provide the public accurate costs of the proposal. It appears that the cost equals the dollar amount of the Congressional appropriation.

...The economics of each pesticide, as well as each application method, should be evaluated.

...There is no indication of the costs for insecticide, application, monitoring, planning, etc. that would be part of the program.

...The DEIS should also have included sufficient information to provide a clear basis for choice among the action alternatives

RESPONSE: Economic costs are projected yearly for each alternative and each analysis analysis unit as discussed in Appendix E, **Treatment Costs**. These data are displayed in the site-specific EA.

Wildlife

Concerning "Some resources such as general wildlife populations, may benefit slightly" (summary p. 7). Reducing lepidopterous insects that are food to song birds could effect their populations.

RESPONSE: Many bird species feed on Spruce Budworm pupae. No known species feeds exclusively on lepidopterous in general or specifically on spruce budworm. Treatment with B.t. and/or carbaryl is expected to substantially reduce budworm populations in the treated areas. The total effect on insect food for songbirds would be greatest using carbaryl, but it is not expected to reduce spruce budworm or any other insect population sufficiently to result in a substantial change in bird populations. This is, at least in part, due to the bird's mobility.

The DEIS (page III-9) misleads the public to believe that some wildlife populations will increase as forested lands return to early successional stages, and those that thrive in older forests will decline. It fails to report, however, that allowing the budworm to run its course will create neither early successional stages nor older forests.

RESPONSE: We agree with you that budworm running its course will change successional stages only in small areas. However, the statement you have quoted was in reference to the changes that are attributable to effects of clearing, logging and wildfire.

However, there are potential hazards associated with insecticide application in sensitive species habitat that are not adequately addressed. The most likely problem would be a reduction of insect pollinator populations, particularly species of butterflies, moths and bees. A second problem, although remote, would involve the burning of foliage after application (i.e. focused light).

If populations of any species deemed sensitive by the Forest Service are found to occur in spray areas, the [Oregon] Dept. of Agriculture would recommend that the following steps be taken: (1) determine if the species will be susceptible to burning due to leafing out or flowering during the scheduled application period; and (2) obtain information pertaining to the pollination requirements of the species. Such information might be obtained through consultations with the [Oregon] Dept. of Agriculture or the Fish and Wildlife Service.

RESPONSE: No population of insects is expected to be eliminated by any of the proposed treatments. A site specific evaluation of the potential impact on pollinators of threatened, endangered, or sensitive species will be made (Refer to Chapter IV, of the EIS).

Is your winter count of the chickadee too low to be effective?

RESPONSE: Effective control of epidemic populations by a single species or any group of insectivorous birds has not been reported.

Limiting wildlife focus of insecticide alternatives to the exposure of game animals browsing on treated foliage will not accurately predict the insecticide exposure of native wildlife which prey on budworms and may concentrate the insecticides their prey has ingested. It is important to identify the native budworm predatory wildlife and predict, for each alternative, the percent mortality of those species in comparison to the percent mortality of the targeted budworm. One should then project the population recovery rates of both the budworm and its native predators.

RESPONSE: The wildlife focus of insecticide alternatives is on several species. It is assumed that all native wildlife insectivores will eat spruce budworms. Many factors, including disease and predation, strongly influence mortality as much or substantially more than the availability of certain prey.

Pages s-15 & s-16:

Wildlife. Alternative D was not discussed under this heading. Why? Does this mean that Alt. D is not a viable alternative as far as wildlife are concerned?

RESPONSE: This alternative was inadvertently left out of the summary. It has been included in the summary of the FEIS.

Page s-15 & s-16:

Under Wildlife Risk Overview, it is stated: "Risks to wildlife are low to negligible in the spruce budworm suppression program." "Alternative C would not present a risk to wildlife." "Carbaryl is considered moderately toxic to mammals and slightly toxic to birds." "Carbaryl is very toxic to honey bees." How would Carbaryl's impacts on bees, especially wild populations, be mitigated? All on the same page we find much confusion. What is the true effect of carbaryl on wildlife?

RESPONSE: A discussion of the potential effects of carbaryl on bees and other wildlife can be found in Chapter IV and Appendix F in the FEIS.

Page s-15 & s-16:

There is no ALT. C listed under Fisheries/Aquatic Ecosystems. Why?

RESPONSE: This discussion was not included in the EIS by mistake, but has been corrected.

Environmental Protection Agency and Oregon State University has demonstrated a 50% mortality to cinnabar larvae during bioassay experiments with B.t., at the rates used during spruce budworm control. Preliminary data shows that the first through third instars (i.e., growth stages) are most susceptible. During the life of the Spruce Budworm Project, the [Oregon] Department of Agriculture should be informed of spray plans on and west of the crest of the cascades, so that critical areas could be identified prior to spraying. This would help to minimize any adverse impacts to the cinnabar moth.

RESPONSE: This is addressed in Chapter IV, Wildlife. Project specific coordination with Oregon Department of Agriculture will occur.

P. Summary--3. B.t. should be spelled out first time used. It would be awkward to do this under "Economics" rather than under "Effectiveness of Treatment Methods," so I'd recommend interchanging these two sections (Also change order of listing at bottom of p. 2).

RESPONSE: The summary has been substantially revised.

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5. Your documentation of the negative impacts of carbaryl on avian species is the repetition of primarily speculative comments and are not based upon fact. Such speculations should be deleted from the Final EIS.

RESPONSE: The impacts of carbaryl on avian species is based on the best available information.

What fish depend on the insects for food and reproductive success?

RESPONSE: Trout and other game fish include insects as part of their food supply. The importance to reproductive success could vary annually.

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(6) Fisheries/Aquatic Ecosystem (page IV-19+) - This section also is particularly disjointed and difficult to follow the USFS decision logic.

RESPONSE: The organization has been improved in the final.

Miscellaneous

When would suppression measures, for budworm, be used under Alternative A?

RESPONSE: Alternative A does not provide for any suppression measures. It is the 'no action' alternative. The outbreak would run its natural course.

It appears to us that a fifth alternative may be needed for consideration. That being a combination of no-action (in some areas) and action (in other areas).

RESPONSE: Additional analyses will be performed on a site-specific basis as each project area is considered. The final action/no-action decisions will be determined at that time. The selection of an action alternative in this document is not meant to imply that all areas infected with western spruce budworm will be treated.

Is it the intent of this document to develop and set forth strategies for long-term management, or will that continue to be left up to the Forest planning process?

RESPONSE: This document develops strategies for management of the current western spruce budworm outbreak. Long-term strategies for integrated pest management will be developed in the next round of Forest Planning.

The history of pest control programs which focus on short-term strategies indicates that they frequently take on a life of their own and are operationally continued beyond their need or when better solutions could be available.

RESPONSE: This FEIS establishes guidelines for determining whether or not areas will be treated. These guidelines are designed to avoid any problems such as the one you anticipate.

Any Environmental Analysis for site-specific suppression measures should be clearly limited to applying the decision of this document, rather than reviewing all available alternatives again.

RESPONSE: The site-specific Environmental Analysis will be tiered to this FEIS. Decisions will be based upon the selected alternative in the FEIS.

In Appendix C, it seems that protesters can be sprayed as long as employees of the agency and contractors are safe and public safety isn't a concern.

RESPONSE: The portion of Appendix C referred to states "If protesters are in the areas, suspend spraying where there is any threat to employees, contractors' employees, or public safety." As members of the public, the intention was that protesters be included in the reference to public safety.

If the Forest Service is to live up to its' stated commitment to have the operational capacity within five years to implement long term pest management strategies, then the agency should spell out for the public: 1) what research it is doing to acquire the base line data needed to make this possible; 2) how it is already implementing, as officials stated at the meeting, the silvicultural and burning practices "seen as a lasting solution to management of Spruce Budworm outbreaks; and 3) what operational changes it has planned to make integrated pest management a reality on national forest lands.

RESPONSE: The implementation of long term pest management strategies is a continuing process within Region 6. The ongoing program includes training, development and testing of mathematical models for forest planning, implementation of a Geographic Information System (GIS) which will allow data base sharing between managers, and the active creation of new positions on the Forest level in entomology and pathology. These positions will provide managers more access to specialized skills and will more fully integrate pest management considerations into management practices. The Region has committed that this integration process will continue to evolve and grow.

The DEIS is lacking maps and visual aids that would indicate the current extent of the outbreak. While summary acreage is presented for historic outbreak areas in Tables I-1 and I-2, the geographic locale suffering infestation remains a mystery. How can the public develop a meaningful understanding of the extent of the problem without maps to aid them?

RESPONSE: Figure I-I in the DEIS is a map of 1988 infested areas. Site-specific EA's will have more detailed maps for proposed project areas.

What areas of susceptible host type currently infested by spruce budworm but in Wilderness or other Congressionally designated area will this plan permit suppression activities to occur on or in? If suppression activities in these areas are prohibited, will there remain a possibly of resurgence of the epidemic from them? How great is the likelihood of this? How does this possibility affect the cost-benefit analysis for the project?

RESPONSE: Suppression activities will only occur on Wilderness when other resources outside the

Wilderness Boundary are threatened. It is not likely that populations within the Wilderness will reinfest the outlying areas. The cost-benefit for projects is not changed by the proximity to Wilderness, since the likelihood of reinfestation is very slight.

Page s-4

What is the effect of budworm treatment/non-treatment on scenic values and recreation use? The preparer went off on a tangent here as he only discussed wood fiber production. Why?

RESPONSE: The effects of treatment and non-treatment on the recreation and visual resources are discussed in Chapter IV of the FEIS.

Page s-4:

The fact that the Forest Service chose two of four alternatives, B and D, as their preferred alternatives leads me to believe that it is difficult for them to make professional management decisions. If the Forest Service chooses ALternative B, they cannot use carbaryl, as is allowed in Alternative D. If the Forest Service chooses Alt. D which allows both B.t. and carbaryl, they do not need Alt. B. D which allows both B.t. and carbaryl, they do not need Alt. B. What is the rationale for choosing both alternatives?

RESPONSE: At the time that the DEIS was published, the Forest Service did not rate either Alternative B or D as preferable. Both were preferred to Alternatives A and C. After review of public response to the DEIS, Alternative E was developed and has become the preferred Alternative.

Pages s-7 thru s-10:

Question #3. Alt. A states: "Implementation of this alternative would not produce impacts to other resources." Yet Alt. A under Question #4 states:"...could result in decreased recreational use, with corresponding impact on recreation economy." Recreation is considered a resource, or the opportunity for recreation is considered a resource.

RESPONSE: The response to Question #3 has been reworded in the FEIS.

Pages s-7 thru s-10:

Question #5. I find it difficult to believe that short-term heavy fuel buildup could be eliminated under Alts. B, C, or D, with the use of *B.t.* and/or carbaryl. This implies that nothing but the western spruce budworm causes heavy fuel buildup. The speed of fireline construction is not dependent on whether the areas have been treated with *B.t.* or carbaryl as stated in Alts. B, C & D or non-treated with *B.t.* non-treatment in Alt. A. Topography is the number one factor in determining or controlling the speed of fire line construction.

RESPONSE: Topography is one factor in rating the difficulty of fire line construction. Another factor is the amount of fuels on the grounds that must be cut through or removed. In areas where mortality attributable to the western spruce budworm is high, the difficulty of fire line construction will be increased.

As stated in chapter III, page 10, more than four hundred species currently on the Regional Forester's sensitive plant list are considered to be endangered, threatened, or sensitive by (among others) the State of Oregon. This statement is not completely accurate, and should be corrected. As provided under the Oregon Threatened and Endangered Species Act of 1987, the Department of Agriculture now has statutory authority for the listing and management of threatened and endangered species of the state. However, this list has had no legal state sanctioning, and references implicating a state role should be deleted to avoid confusion.

RESPONSE: This section has been reworded to eliminate any confusion.

In chapter IV, page 19, as listed under Threatened, Endangered, and Candidate Species, there is no Alternative C discussed.

RESPONSE: This omission has been corrected in the FEIS.

In most of chapter IV, references cited in the text and summary are not listed in the bibliography-Appendix R. In fact, the bibliography contains only references dealing with pesticides. Also, references cited on page 1 of Appendix N are not listed. We recommend that a complete bibliography be included in the final document.

RESPONSE: The bibliography has been updated and expanded for the FEIS.

(EPA 1981). The DEIS lists 21 EPA reports or studies in its cited literature, but not the 1981 document quoted above.

RESPONSE: This omission has been corrected for the FEIS.

Summary, page 1. Introduction, paragraph 5 versus Decision Needed, paragraph 1.

Some clarification may be necessary here. (See APPENDIX D, Prevention, par. 2.)

Summary, page 4, Planning Questions

RESPONSE: This portion has been rewritten to improve clarity.

Question 2. Question pertains to effectiveness. Response is incomplete. Information regarding impact is superfluous and could be deleted.

RESPONSE: We have deleted the superfluous material and rewritten the question description.

The potential for population collapse should be studied and evaluated in terms of control costs/benefits.

RESPONSE: The estimated duration of an epidemic on a specific site will be used in determining the cost/benefits for proposed projects. The economic analysis considers this and factors in the number of treatments which may or may not be required.

Use of different assessment methods, including spray cards with dye should be evaluated.

RESPONSE: Spray cards are being used at this time to determine the completeness of treatment coverage. Other monitoring methods are discussed in Appendix C, Standards and Guidelines.

Summary - l, Decision Needed, first paragraph.

Clarification is needed as to whether this document and process addresses the future or current problem; or both. We do not feel that the NEPA process should be addressing and determining what should be done on non-federal lands. We understand that constraints can be placed on actions on non-federal lands if federal funds are involved. This distinction should be clarified in the document.

RESPONSE: This is a programatic EIS and addresses treatments that are proposed during the current outbreak cycle. It discusses projects that are proposed for both federal lands and cost-share cooperators' lands. Cooperators are bound by this EIS only if they are participating in a cost-share program.

Summary - 5, Forest Service Goals, first paragraph.

The document states, "These objectives are attained on non-federal lands through cooperation with State Foresters."

We recommend the word "are" be changed to "may"; and in the last sentence, "private lands" be changed to "non-federal lands."

RESPONSE: We have made your recommended changes.

Treatment History

Appendix N-2, Column 1, fourth paragraph.

In regards to the 1988 Boise Cascade project in Oregon, "rumors are that results were excellent". The NEPA process should not deal with rumors, but facts and data as much as possible. We suggest you contact the company and ask permission to use their data.

RESPONSE: We have made the change suggested, and have included the data in the FEIS.

Wilderness

Summary - 18

The document states, "The life cycle of the western spruce budworm suggests the lack of treatment in wilderness does not pose a threat to non-wilderness adjacent lands." We don't understand this statement at all! In the second column under alternatives B, C, and D, it says, "Insecticide application would interfere with the natural processes which are a key part of the wilderness resource." This is the true reason why treatment may not be done in the wilderness; not the "life cycle" of the insect.

RESPONSE: Natural processes are allowed to continue in wilderness areas with a few exceptions. One exception is that wilderness may be treated if the epidemic threatens resources outside the Boundary. The life cycle of the budworm is not conducive to invasion of adjacent areas, and so does not pose a significant threat to these resources.

All citations in Chapter IV and Appendix N in the main document should be checked to make sure they appear in the Bibliography (Appendix R). Several that did not appear include:

CitationPageColumnParagraph

Alfaro, et al 1982 IV-5 2 1

Crimp, 1982 IV-5 2 1

RESPONSE: We have updated the document and included all references cited.

The DEIS also erroneously implies in numerous places (e.g. page Q-5) that "sites are normally treated once per year". We at Boise Cascade see no need, and have no intention of treating once per year. Once per

decade is even out of the question on much of the infested lands. Statements such as these create unnecessary alarm among the general public.

RESPONSE: We have reworded this portion to more accurately portray the potential treatment regime.

---

3. The DEIS fails to analyze all reasonable alternatives, as required by the National Environmental Policy Act.

RESPONSE: The DEIS has analyzed a reasonable range of alternatives within the scope of the document.

---

4. Forest Service should issue a supplement to the EIS and describe a long-term management approach that includes recognition of the need for short-term management on selected sites (e.g., visual and recreational sites.)

RESPONSE: The long term management approach, or Integrated Pest Management, will be discussed in the next round of Forest Planning.

---

a) NCAP was omitted from the list of participants in the Forest Service scoping process. In addition to a face to face meeting with the team leader, NCAP submitted four pages of scoping comments for the team's consideration.

RESPONSE: We apologize for the omission, and have made the appropriate addition to the list.

---

b) Page numbers are missing from Appendix F, making it extremely difficult for commenting purposes.

RESPONSE: Appendix F has been reformatted into a more readable style.

---

c) The specialties, expertise and roles of the interdisciplinary team members have not been identified. That would be helpful for the public.

RESPONSE: This has been included in the FEIS.

---

5. Appendix F is a miserable, shoddy risk assessment discussion for the public. There are no page numbers and no table of contents for it even though it is over 230 pages long. Anyone trying to read it has to wade through analyses of malathion and acephate even though the EIS is not proposing use of either of these chemicals. No analysis is offered of the quality of studies cited and critical studies have been omitted.

RESPONSE: Appendix F has been reformatted into a more readable document. A table of contents has been included. Malathion and acephate were analyzed before development of the Alternatives and the material is included here as a reference.

The DEIS should provide specific citations to data and studies. Then it should incorporate and evaluate this information on a site specific basis.

RESPONSE: The EIS cites professional papers consulted in document preparation in the Reference appendix. Site specific evaluations will be done in Environmental Assessments which will tier to this EIS.

In summary, I feel the DEIS likely contains the information necessary to meet NEPA and NFMA requirements, but must be laid out in a more organized, systematic manner in the final EIS.

RESPONSE: Several portions of the EIS have been rewritten.

---

7) The Forest Service should undertake scientific and controlled tests under actual conditions (i.e. test plots) to determine the most effective combination of control products to use. Particular attention should be given to study the effect of combining two or more insecticides as a means of retarding the development of resistance by the budworm. This method has been proven effective in other insect control areas, such as mites.

RESPONSE: The Forest Service has been conducting product tests, and plans to continue study methods of direct control.

We would like to see lobbying by the agency stepped up to acquire research funding not only for Spruce Budworm studies but studies of other insect pests likely to remain endemic in the region's ecosystem.

RESPONSE: We agree there are many research gaps for major insect pests. Funding levels for Forest Service research are established by Congress. As a Federal Agency, the Forest Service can not lobby Congress for increased funding.

I also strongly urge an expanded research program to develop silvicultural and stand management strategies to reduce susceptibility of present stands to repeated [S]pruce [B]udworm infestation. When research has developed management strategies more resistant to budworm infestations, action programs should follow.

RESPONSE: In the long term, appropriate silvicultural management will help reduce the impact of western spruce budworm. While some strategies are available now, more research and information is needed. We are continuing to encourage and support

research in this area in order to identify and implement more opportunities.

Past and current levels of research funding are grossly inadequate to support even known research needs and prospects for significant increases are dim unless decisive management action is taken.

The Final EIS could remedy this deficiency in part by:

-including among its planned actions a credible and operationally sound set of funded research activities which will contribute to environmentally sound long-term solutions.

RESPONSE: Research and the National Forest System (NFS) are separate branches of the US Forest Service, and as such, budget levels are set separately by Congress. The EIS can support the position that additional research is needed; however, the NFS does not have the authority to fund or plan activities for Research. The above recommendation is beyond the scope of this EIS.

A list of Respondents follows:

List of Respondents:

1	Wally Eubanks
2	Catherine Kolstad
3	Walter & Dorothy Pelech
4	Ellen Switzer
5	Lawrence M. Jacobson
6	E. Zahn
7	John J. Townsley
8	Arnie Kubiak
9	Ben Iverson, P.E.
10	Arleigh G. Isley Oregon State University Extension Service
11	Albert L. Wellman
12	Gary W. Blanchard Starker Forests, Inc.
13	Ginny Irving
14	Effie Skinner
15	D. L. Walker Oregon Department of Transportation
16	Ernest B. Price, Jr.
17	number not used
18	Jerry Havel
19	Kenneth Galloway, Jr.
20	number not used
21	Scott Winslo
22	Dennis K. Zacha
23	Dean B. Guess
24	Paul C. Bell
25	Michael Cooper
26	Anthony Sowers Half-Baked Enterprises
27	A. T. Reinhart Douglas Timber Operations, Inc.
28	Neal Walker Chamber of Commerce Roseburg, Oregon
29	number not used
30	Bill Dougan
31	Mitch Friedman
32	Ethel Thornilery
33	Kris R. Brotherton
34	Michael Hill
35	Scott H. McKenzie Curry County Soil & Water Conservation
36	W. H. Kosesan Oregon Department of Agriculture
37	Robert L. Berger L. A. Washington State Dept. of Transportation
38	Frank Vaughn
39	G. Peter Ellingson
40	Thomas C. Adams
41	Stan Benson
42	Jim Clarke
43	Teresa Carp Sierra Club - Oregon Chapter
44	Krystyna Wolniakowski American Fisheries Society
45	Ronald S. Yockim Prarie Wood Products
46	Bob Platz Western Forest Industries Association
47	Leroy N. Kline Oregon Department of Forestry
48	Bruce P. Alber
49	number not used
50	P. B. Lauterbach
51	J. P. Hess
52	Greg McGuire
53	number not used
54	number not used
55	Robert C. Messinger
56	Richard W. Williams
57	Marion W. Fisk
58	Kevin M. Arneson
59	Bill Dryden Boise Cascade Corporation Timber and Wood Products Group
60	Dolores Streeter State of Oregon - Executive Department
61	Ken Shrum East Oregon Forest Protective Association

62 William J. Weiler
Washington Environmental
Council
63 Lynn A. Brown
U.S. Department of Agriculture
Soil Conservation Service
64 Charles S. Polityka
U.S. Department of the Interior
Office of Environmental
Project Review
65 number not used
66 Janet & Kenneth Nolley, MSW, Ph.D.
67 Jerry Stroyan
68 Steven D. West
69 Joel L. Thompkins
70 Jeffrey L. Weatherly
71 Michael G. McGreevy
72 Lyle K. Eddings
73 Steven R. Tueit
74 David K. Whitwill
75 Richard D. Just
76 James W. Harbend
77 Art Stearns
Washington State Department
of Natural Resources
78 Don Carlton
79 David E. Clapp
Department of Health and
Human Services - Centers
for Disease Control
80 Michael G. Banfield
Consep Membranes, Inc.
81 Gary Weiher
Boise Cascade Corporation
Timber and Wood Products
Group
82 Wayne Loudeman
83 Bruce K. Beckett
84 Roger Goff
85 Michael N. Pieti
86 Sherry A. Scott
87 David A. Oldham
88 Harley M. Berger
89 Gerald Pyle
90 Sherri Pond
91 Howard Jackson
92 Alan E. Beaudry
93 Willis A. Cawley, Jr.
94 D. W. Mumper
Weyerhaeuser
95 Norma Grier
Northwest Coalition
for Alternatives
to Pesticides
96 Mary Nelson
Willapa Hills Audubon
97 Ronald A. Lee
U.S. Region 10
Environmental Protection
Agency
98 Dick R. Malcom, Jr.
Washington Forest
Protection Association
99 Timothy Coleman
100 Jean C. Meddaugh
Oregon Environmental
Council
101 Ken Karr
102 S. T. Wapato
Columbia River Inter-
Tribal Fish Commission
103 Richard L. Brathovde
104 Terry L. Witt
Oregonians for Food
and Shelter
105 Richard T. Bailey
Northwest Forestry
Association
106 Ernie Soya
107 Clark T. Rogerson
108 Bruce M. Niss
City of Portland, Oregon
Bureau of Water Works
109 Lola Loudis

The following are letters received in response to the Draft Environmental Impact Statement. No letters were given the numbers 000017, 000020, 000029. These sequence numbers were used for training purposes. The letters which received numbers 000049, 000053, 000054, 000065 were duplicate responses.

10/24/88
410 Evans N.
Salem, Ore
97303

000001

Concerning Draft EIS
Management of Spruce Budworm
in Ore. & Wash.:

Thanks for the EIS copy & chance for comment.

Having followed the course of events in insect control in Oregon by the State Agric. Dept., in California & by USFS & BLM I find that you offer a pretty good set of alternatives in this EIS. You have set out the issues & concerns where they really are.

I urge the F.S. to go with alternative (B).
The effectiveness of B.T. has been proven in other projects & with its long term effectiveness against the Budworm while having practically no bad side effects is all to its advantage.

Alt. (C) is unacceptable. Has been used before & never wiped out the insect. (probably created a tougher type budworm). The chemicals have bad effects on all other forms of life.

Alt. (D) is also unacceptable. I have learned that it is impossible to control spray drift & know that one swath barrier is as good as no barrier. I have had spray pilots tell me how clouds of their spray have drifted for miles on a little wind.

If the cost of B.T. is a little higher - so what - what's the value of other beneficial insects, birds & animals not to mention some supersensitive people.

Thanks, Wally Eubanks

28 Oct. 1988

Forest Service Personel,

000002

Thank you for sending me the Environmental Impact Statement on the W. Spruce Budworm.

After reading the information on all the plans of action, My Choice is Alternative A - No Action.

I think to allow the bud worm infestation to follow its natural course is much better than tampering with the natural balance of the forest thru using chemicals.

I am very concerned about the possibility of using Alt. C or D that uses Carbaryl. I have heard stories myself about the accidents that do happen with the application of chemicals - polluting streams.

Our environment and human health should be our 1st concern here with this issue. That is why Alt. A makes good sense.

-2-

I am hoping that no Carbaryl need be sprayed on our forests - I feel it is unsafe to use even with a buffer of B.t. as the rain would wash the residues into our water. Ariel spraying seems very dangerous and hard to control.

Again my vote is for Alternative A.

Please let me know what action will be taken.

Thank you

Catherine Kolstad
95905 Hwy 101
Yachats, Oregon
97498

5122 East Citrus Street
Tucson, Arizona 857
November 4, 1988

Mr. Roger M. Ogden
Western Spruce Budworm Project Leader
319 SW Pine, P.O. Box 3623
Portland, Oregon 97208

000003

Dear Mr. Ogden:

The No Action - Alternative A should be the preferred method of dealing with the budworm.

Alternatives C + D should certainly not even be considered because the insecticide carbary should never be used because of its effects on wildlife and humans.

Alternative B (Bacillus Thuringiensis use) should not be used because not enough is known about the far-reaching aftereffects of its use. What about reproductive and carcinogenic potentials?

As stated on page 18 of the Summary, the budworm is "an indigenous component of the forest environment."

If man leaves Nature alone, Nature will sooner or later take care of itself.

Sincerely
Walter + Dorothy Pelech

000004

I would like to express my concern regarding the management methods for controlling the spruce budworm infestation in the Pacific Northwest.

I am opposed to the use of chemicals for forest management. The risk to other animal, plant & human life is too great.

Ellen Foster

Dear Mr. Ogden,

I agree with the preferred alternative in the Draft EIS on Spruce Budworm Mgmt. I prefer Alt. B over alternative D. Why not try Bt first. If it really fails then try Alt. D. If Bt only is mostly successful, that's good.

Any plans to stop the spread west of the cascades. Is it likely to be carried by camper trucks?

LAWRENCE M. JACOBSON
2628 113TH WAY S.W.
OLYMPIA, WASH. 98502

Sincerely,

Lawrence M. Jacobson

The Regional Forester
The Pacific Northwest Region
The USDA Forest Service
319 SW Pine, PO Box 3623
Portland, Oregon 97208,

000006

Thank you for a fine summary of the DEIS for the management of Western Spruce Budworm which is the cause of concern for the effects of treatment are serious as there is toxic chemical spray drift and the problem of non-specificity.

The long term solution may be the best one--return to the concept of mixed stands because the spraying with specific or non-specific - effect sprays is done at the time of spring birthing for wildlife.

The effect on human health seems to be limited in information--whether carcinogenic or having ~~a~~ skin effects when there are gastro-intestinal and respiratory effects on humans and wildlife.

The Alternative A is preferable as there will be jobs and timber with the harvesting of damaged timber and the reforestation with mixed stands.

The responsibility for natural control of insects is one that the community should have to assume as the community is responsible for the extensive stands of Douglas fir and for the increased American population, 18 million increase in the last ten years? We are told that morality for people (birth control?) is a need.

With best wishes for the success of Alternative A to correct the problem, E. Zahn
295 Fleet Drive, Port Ludlow, WA 98365
October 31, 1988

E. Zahn

21 October 1988

000007

John J. Townsley
P. O. Box 586
Okanogan, Washington 98840

Regional Forester
Pacific Northwest Region, USDA, FS
P. O. Box 3623
Portland, OR 97208

I have the following comments regarding the **DEIS** for *Management of Western Spruce Budworm in Oregon and Washington*.

1. The DEIS considers treatments that will form a "strategy for managing the current outbreak."[1] Yet "[t]here is a concern that our past silvicultural practices have led to species composition and stand conditions that are susceptible to spruce budworm."[2] Neither preferred alternative addresses the fact that stands are predisposed to spruce budworm damage. Treatment costs are predicated upon the assumption of one or at most two treatments.[3] The validity of this assumption is not substantiated. What is the probability it is in error, and what is the expected cost of <u>subsequent</u> treatments should the current epidemic resurge as similar infestations have in the Rocky Mountain Region of the USFS? The expected cost of subsequent treatments should be considered in the economic analysis.

2. A number of Eastside National Forests in Oregon and Washington[4] are seriously considering various intensities of uneven-aged management in their Final Forest Plans. Uneven-aged management will perpetuate stand conditons that are favorable to the development and spread of spruce budworm. How is the deliberate creation of defoliator habitat reconciled with the preferred suppression strategies proposed in this management plan? The document fails to disclose the likely effects (in terms of future endemic and epidemic

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1. DEIS I-3.

2. DEIS I-6.

3. DEIS II-3.

4. Personal Communication with various R6 silviculturists.

populations and the resulting economic and growth opportunity costs) associated with proposed Forest Service silvicultural practices.

3. The document notes that in both preferred alternatives "[c]urrent practices in the infested areas would continue." and that "[s]ilvicultural prescriptions may be changed to respond to damage to forest stands."[5] What constitutes "current practices" and how silvicultural precriptions might be modified is unclear. Will this require greater reliance upon even-aged methods, or will uneven-aged methods be applied as is being considered for inclusion in some Forest Plans?

4. Nowhere in the DEIS is there a meaningful discussion of the aggregate effect upon local and regional harvest levels that would result from selection of any one of the four proposed alternatives. Given that the ultimate reason for managing the forest for wood products is its beneficial effect upon the human environment, this seems to be a serious omission. How is it possible to estimate economic effects resulting from any of the alternatives, let alone make a rational selection from among them in the absence of this information? What are the implications in terms of employment, receipts to counties and local governments, and maintenance of essential social services that will result from any of the proposed alternatives? The DEIS should provide in tabular and graphic form quantitative estimates of <u>projected</u> volume production, employment (direct and indirect), receipts to counties, and local service levels for both local and regional economies.

5. While Appendix G presents a detailed discussion of the methodology used in the analysis, it provides very little information regarding the actual results. Nowhere in the document is the quantitative information displayed that would indicate the analysis was actually conducted. I am left with the impression that there was an analysis plan prepared, but that somehow the required analysis was never complete.

6. The DEIS is lacking maps and visual aids that would indicate the current extent of the outbreak. While summary acreage is presented for historic outbreak areas in Tables I-1 and I-2, the geographic locale suffering infestation remains a mystery. How can the public develop a meaningful understanding of the extent of the problem without maps to aid them?

---

5. DEIS II-3.

7. The DEIS does not give a clue to the reader/public regarding what specific areas might be considered for treatment in the current outbreak. What are the criteria the USFS will use to determine appropriate areas to treat? Based upon these criteria, what areas are likely to be proposed for treatment by methods proposed in either preferred alternative?

8. How does this document (the Spruce Budworm DEIS) relate to Forest Plans now in various stages of completion about Region 6? How will selection of any one of these alternatives affect proposed harvest levels published in Draft Forest Plans, or in future Final Forest Plans? Did Forest Plans account for the effects of epidemic vs endemic spruce budworm in their volume projections?

9. What areas of susceptible host type currently infested by spruce budworm but in Wilderness or other Congressionally designated area will this plan permit suppression activities to occur on or in? If suppression activities in these areas are prohibited, will there remain a possiblity of resurgence of the epidemic from them? How great is the likelihood of this? How does this possiblility affect the cost-benefit analysis for the project?

Thank you for this opportunity to comment. Please send me copies of the Final Environmental Impact Statement and Decision Notice when they are prepared.

Sincerely,

John J. Townsley

Arnie Kubiak
9975 Manitou Beach Drive NE
Bainbridge Island, WA 98110

000008

October 27, 1988

USDA Forest Service
Pacific Northwest Region
319 S.W. Pine Street
Portland, OR 97208-3623

ATTN: Western Spruce Budworm Management

After reviewing the DEIS for the Management of Western Spruce Budworm I believe Alternative B with modifications to be the best management scheme.

The minimal risk, to human health, from the use of B.t., its apparent effectiveness, and the small range of affected organisms to the toxic effects of B.t. makes it superior to Carbaryl.

Due to the data gaps and the small possibility of other contaminants in the formula, riparian buffer zones should still be employed when spraying any insecticide including B.t.. Control areas throughout the range of infestation should be maintained to verify the effectiveness of the management program. Selective cutting and silviculture techniques to return the forest back to its natural diversity should be employed throughout the area. Furthermore all future harvesting of trees should be through selective cutting designed to maintain a sound balance of species and age groups.

To summarize I support Alternative B with the following modifications:

1.) buffer strips for riparian zones
2.) control areas throughout range where no spraying is performed
3.) selective cutting to be required on all future harvest to minimize possibility of creating unnaturally favorable climate for infestation.
4.) silvicultural techniques to return stands to a sufficiently mixed state.

I also approve of your organizational changes to improve the monitoring and response time to management problems.

Sincerely,

Arnie Kubiak

I.B. (Ben) Iverson
Civil Engineer
Registered: Washington
California
Alaska

October 24, 1988

30211 S.E. 40th St.
Fall City, Washington
98024
Ph. (206) 222-5903

000009

U. S. Forest Service
P. O. Box 3623
Portland, Oregon, 97208-3623

I have read the DEIS (for comment to Dec. 22, 1988) and come to the conclusion that chemicals must be ruled out as a solution to the Spruce budworm problem. But b.t. is probably okeh. The chemicals destroy the natural predàtor, even though that natural predàtor has not been found. It could possibly be b.t.

Take your cue fromthe use of roadside spray of chemicals: In areas where herbicides are used, the webworm and caterpillar infestations are the worst. In areas where chemicals havenot been used, any major outbreak of the webworm is a one-season event, if such an event happens,and killing of the host plant is rare.

Spruce budworm certainly has a preditor because there were no forest-wide infestations before 1970. The natural predàtor has probably been destroyed by disturbance of the ecological balance by chemicals. This allowed infestations to occur, as you say, "for the past 8 years" or nearly as long as USFS has been using chemicals.

This DEIS appears to be principally a political document and will lead to a political decision,rather than maintaining a scientific basis and holding to balanced scientific fact. It is this type of faulty reasoning which has given us the ozone hole, the greenhouseeffect, acid rain, and the pollution of our air, water, and soil.

Ben Iverson

Ben Iverson, P.E.

It appears to me, that the winter chick-a-dee is the major predàtor of the webworm by feeding on the egg masses. Is yourwinter count of the chick-a-dee too low to be effective?

Roger Ogden & Co.

EXTENSION SERVICE
Wallowa County Office

Oregon State University

P.O. Box 280
Enterprise, Oregon 97828

(503) 426-3143

000010

October 28, 1988

F.S.
1988
PRIVATE FORESTRY

Mr. James Torrance
Regional Forester
319 SW Pine
Portland, OR 97208

Dear Mr. Torrance:

assume means WSBW

After carefully reading the U.S.F.S. draft EIS for tussock moth control, I support alternative D for short-term control. However long-term control must be accomplished through improved forest management practices.

The current situation with western spruce budworm and tussock moth was predictable and reflects the concerns some of us involved in resource management expressed as long as twenty years ago.

Fire control and silvaculture practices that allowed spruce and fir to inhabit sites that are ecologically unsuited to those species have created a series of problems that cannot effectively be resolved. The only long term solution will require careful ecological analysis of each forest area and the growing of specific species adapted to that site. Ecology and history both tell us that white fir and spruce in pure stands inhabited only small areas often high in drainages of Eastern Oregon. These areas were usually quite small and if they became infested only a small area was involved. Large areas of a single species, particularly in overstocked stands are always susceptible to insect, disease and fungi attacks.

The obvious problems with pine beetle in lodge pole should have alerted forest managers to the need for diversity and ecologically adapted species. However large areas of lodge pole are being promoted because it grows fast and is a quick source of soft wood fiber. The only problem with this management approach is only a small part of the wood fiber produced will get to society as a usable product. In many areas as many as 5000 stems are present per acre. There is no way these trees can grow as they should. The result is overstocked stands, poor growth, lack of vigor and potential fire hazard where control is impossible. Thinning and other cultural practices are ineffective and expensive. In addition range forages are crowded out, wildlife species, particularly big game and upland game birds habitat is lost.

Aggressive management where the proper species is produced on the ecological site it is best adapted to with properly stocked stands is the only effective way to deal with these problems.

Once these stands are cleaned up, controlled burning on a regular basis will be necessary to maintain proper conditions to alleviate insect and disease problems and to control forest fires. The idea that we can allow uncontrolled burns under the current conditions is unfounded. Prior to fire control, fuel loads in eastern Oregon were from five to fifteen tons per acre. Today they generally range from ninety to one hundred twenty. A forest fire with over twenty tons of burnable fuel per acre is going to cause considerable damage because it will change from a ground fire to a crown fire.

Some specific approaches to getting on top of these management problems are:

1) Create corridors of well managed forests. They will be mostly fire proof and have little insect and disease problems. With limited resources only a small part of the forest can be treated.

2) Use management and cultural practices that promote species well adapted to the ecological conditions that exist.

3) Promote diversity of species and openings within the forest area.

4) Use management and cultural practices that create habitat for beneficial forest fauna. As an example, we need more insect and herbivore type birds than raptorial.

5) Use decision making processes that promote the use of sound management principles based on scientific facts and not popular myths. It is appropriate for the public to have input in resource management decisions as long as the public is well informed and can produce intelligent input. However a loud clamor of voices based on ignorance does more harm than good regardless of how good the intent is.

6) Through the political process, insure that those responsible for decisions are given responsibility for their decisions and if the decisions are good, they are rewarded, and if the the decisions are poor, the ones causing that course of action are penalized. Authority without responsibility is intolerable in any management situation. Therefore any special interest group that exercises enough influence to cause poor decisions that result in significant cost to society should be held accountable for that cost plus punitive damages so careful consideration will be given to the consequences of each decision made.

All testimony given at public hearings should be subject to perjury laws. Anyone guilty of providing false testimony should be subject to criminal prosecution.

Sincerely,

Arleigh G. Isley

Arleigh G. Isley
Extension Agent

AI:ms

3 November 1988

Mr. Roger M. Ogden, Western Spruce Budworm Project Leader
USDA Forest Service, Pacific Northwest Region
319 SW Pine, Post Office Box 3623
Portland OR 97208

000011

I have reviewed the summary of the draft environmental impact statement for managing western spruce budworm in Oregon and Washington. That document's myopic discussion of wildlife concerns and effectiveness of treatment methods apparently overlooks the significant relationship of these two concerns through food webs and predator-prey relationships in a balanced forest ecosystem. Examining wildlife and effectiveness separately may produce incorrect conclusions.

North America's western fir forests have survived the spruce budworm for centuries because native predators have held budworm populations in check. Although primeval budworm population cycles may be undesirable from the standpoint of present forest management practices, and present forest management practices may even increase the severity of budworm population cycles; it is important to recognize that native budworm predator species, aside from their intrinsic wildlife value, may still exert a subtle but significant control of budworm populations.

Limiting wildlife focus of insecticide alternatives to the exposure of game animals browsing on treated foliage will not accurately predict the insecticide exposure of native wildlife which prey on budworms and may concentrate the insecticides their prey has injested. It is important to identify the native budworm predatory wildlife and predict, for each alternative, the percent mortality of those species in comparison to the percent mortality of the targeted budworm. One should then project the population recovery rates of both the budworm and its native predators.

Predator population cycles normally trail prey population cycles; so alternatives which significantly reduce native budworm predators can be expected to increase the severity of future budworm infestations. This may create a management dependance upon continuation of budworm control measures. If such dependance can reasonably be projected, it should be added to the relative costs of the considered alternatives. Furthermore, some native budworm predators may also be effective in controlling other insects which are damaging to forests, agriculture, wildlife, or recreation. Damage to those predatory species could result in increased damages from other insect pests. Such damages should also be considered in the relative costs of alternatives under consideration.

I hope you will be able to expand environmental review of this project to include more specific attention to native wildlife predators of the spruce budworm.

Albert L. Weilman
~~662~~ Green Way
Santa Rosa CA 95404

cc: Senator Alan Cranston
Senator Pete Wilson
Congressman Doug Bosco

000012

STARKER FORESTS, INC.

7240 S.W. PHILOMATH BOULEVARD
P.O. BOX 809
CORVALLIS, OREGON 97339
TELEPHONE (AC 503) 929-2477

B. Bond Starker, President
Barte B. Starker, Executive Vice-President
Elizabeth Starker Cameron, Corporate Secretary
Gary W. Blanchard, Chief Forester

Wait on g corresp.
WWC

October 28, 1988

Mr. James F. Torrence, Regional Forester
U. S. Department of Agriculture
Forest Service
P.O. Box 3623
Portland, Oregon 97208-3623

Dear Jim:

This is in response to your 10/17/88 update on the western spruce budworm infestation. We appreciate your interest in our opinion.

If this problem was occurring on our property we would take immediate action to eliminate the pest. We would expect to take some flak from the obstructionist community but we feel landowners have an obligation to protect their own resources and a social responsibility to curb pest epidemics which threaten neighboring landowners.

The organizational changes you refer to seem reasonable but we hope you will use the established research personnel and facilities (PNWF&R Exp. Sta) and Oregon Forest Research Lab to conduct and analyze research. Don't get bigger - get better.

Thanks again for keeping us informed.

Very truly yours,

Gary

Gary W. Blanchard
Chief Forester

F.S. RECEIVED R-6
NOV 3 1988
STATE & PRIVATE FORESTRY

GWB:cs

Orig: FPM ✓
cc: DRF, S+PF

F.S. R-6
RECEIVED
NOV 3 1988
Regional Forester

FOREST LANDOWNERS AND MANAGERS SINCE 1936

000013

November 5, 1988

Dear Roger,

I am very interested in the spruce budworm control project in Oregon.

I am especially concerned about poisons being sprayed in areas my children and I like to hike, camp, and pick berries in.

Please send me a copy of the environmental impact statement released in October.

Thank you,
Ginny Irving
26 Prospect Ave
Hood River, OR
97031

Nov 2/88

US Forest Service Region 6
Portland, Oregon

000014

To Whom it May Concern —

Last nite on our local TV KIMA Channel 29 I heard US Forest Service had Released yet Another EIS Regarding Spraying The Natches - Rimrock Lake area for Spruce Budworm.

I wonder to whom it was released! I'm normally on your mailing list and have not Recieved any notification. Please Send me a notice!

I'm Very much in opposition to Carbaryl being Sprayed on The Yakima watershed - in an area where a lot of fishing + Recreation is done.

I would like to know if you are merely Recieving written Comments or if you intend to hold public hearings as well? Thankyou!

Sincerely

Effie Skinner
14110 Cottonwood Cyn Rd
Yakima, WA. 98408

STATE OF OREGON 1859

NEIL GOLDSCHMIDT
GOVERNOR

Department of Transportation

PARKS AND RECREATION DIVISION

000015

REGION II OFFICE, 3600 E THIRD STREET, TILLAMOOK, OREGON 97141

October 28, 1988

F.S. RECEIVED R-6
NOV 1 1988
STATE & PRIVATE
FORESTRY

James F. Torrence
Regional Forester
U. S. Forest Service
319 S. W. Pine Street
P. O. Box 3623
Portland, OR 97208-3623

Dear Mr. Torrence:

From a brief look at the Draft Environmental Impact Statement Summary on the Management of the Western Spruce Budworm in Oregon and Washington, it appears that alternative B is the reasonable one that will address environmental concerns--both for the health of the forest and of the public. "A" ("Do Nothing") is equally unacceptable as compared to "C" and "D," which are alternatives that use a potentially harmful chemical.

However innocuous B.t. appears to be, research should continue so no questions on its environmental and health impacts remain--especially carcinogenicity and reproductive and developmental toxicity concerns.

Thank you for the opportunity to comment.

Sincerely,

D. L. Walker

D. L. WALKER
Region II Park Supervisor

DLW:sjp:spbudwor.ltr

000016

November 10, 1988

James F. Torrence, REGIONAL FORESTER
Pacific Northwest Region
USDA Forest Service
319 SW Pine, P.O. Box 3623
Portland, OR 97208

Dear Mr. Torrence:

Thank you for the opportunity to give you my comments on the Draft Environmental Impact Statement for Managing Western Spruce Budworm in Oregon and Washington.

I have read the Summary and have the following comments:

I believe that the concerns of the use of "carbaryl" is real to some people but I do not think the concerns are justified. I have used [redacted] "carbaryl" both the liquid and powder form in my vegetable and flower gardens without consequence either to my family or to bees. I of course I follow the directions on the label and apply the insecticide in the evening.

I believe that you really must consider treatment on commercial forest land separately from wilderness.

I is clear to me that Alternative A must be selected for wilderness areas in order to meet the management objectives for those lands.

It is also clear that the most cost effective Alternative should be selected for the commercial forest land. The Summary does not spell out the economic differences between Alternatives but I assume that Alternative D which provide for the use of Bt and carbaryl is the most cost effective. If this is true then Alternative D should be selected.

Where a budworm epidemic is located in a wilderness and it threatens adjacent lands, treatment with in the wilderness should be limited but enough to prevent the insect from damaging the commercial forest.

Sincerely,

Ernest B. Price

ERNEST B. PRICE, JR.
P.O. Box 1125
Lakeview, OR 97630

LA GRANDE
PUBLIC SCHOOLS

SUPERINTENDENT
Richard D. Prather

0ST
O&RF

November 4, 1988

000018

James F. Torrence
Regional Forester
P. O. Box 3623
Portland, OR 97208-3623

Dear Sir,

I have received and read with great interest the Draft Environmental Impact Statement summary for the management of western spruce budworm.

While I do not usually endorse the use of any herbicide, pesticide, or insecticide I can see where their judicious use is sometimes justified. In this particular situation, although there is solid rational for the use of B.T. and carbaryl, I do not believe it is the best choice of the two preferred alternatives. There is always the chance of drift and/or leaching of the carbaryl into streams and lakes contained within the affected area. The added possibility of resistance also adds to my concern.

I am vitally interested in the environment and the continued beauty of Oregon.

One of my sons has recently graduated from the School of Forestry of Oregon State University. We have had many long and enlightening conversations dealing with conservation and the environment -- about the methods available to counteract natural devastation. The quick and/or easier way is not necessarily the best for the long run.

While neither Alternative B or Alternative D would be the quick fix I strongly feel that Alternative B is my choice to be used for the suppression of the spruce budworm infestation.

Sincerely,

Jerry Havel, Supervisor
Plant/Operations
963-1914

JH/jks

OPPORTUNITY & EXCELLENCE

Union County School District Number One
1208 Fourth Street La Grande, Oregon 97850-2179 503-963-1902

FORESTRY DEPARTMENT
KENNETH GALLOWAY, JR.
FOREST MANAGER
918 18th STREET
HOOD RIVER, OREGON 97031
PHONE: (503) 386-6323

November, 10, 1988

To: Roger M. Ogden

Subject: Spruce Budworm Project

000019

Dear Sir:

Since I am keenly aware of the planning, work and the net results of a Spruce Budworm project, and since I have seen the results of several U.S.F.S. and private spray projects, the following are my suggestions:

First,because the extremely good results of the U.S.F.S. Sevin-4 with oil projects of the early 1980's, private industry spray project results and those of the recent Hood River-Longview Fibre project, Sevin-4 with oil (Carbaryl)should be the main chemical planned to use. Not b.t.!

Second, because of some, but not the entire forest system is sensitive because of human use, water, or distinct environmental concern, b.t. should be used in these areas including buffer strips. This would not allow the insect population to go unchecked.

Third, areas that are not to be sprayed, need to have an adequate natural or sprayed area and sound reason not to be sprayed.

Fourth, he U.S.F.S. should spray an adequate area around private timber holdings to minimize loss to the private land owner when they are going to spray, and the U.S.F.S. is not. This will at least assure that the efforts of the private landowner will not be infected by the insect just because the U.S.F.S. does not have a full project.

In conclusion, the only viable alternative that the U.S.F.S. has that is a sound and reasonable professional forestry and social decision is to use carbaryl and where necessary use b.t. Thank-you.

Sincerely,

Kenneth Galloway Jr.

HOOD RIVER COUNTY
FRUIT RECREATION INDUSTRY

FORESTRY DEPARTMENT
KENNETH GALLOWAY, JR.
FOREST MANAGER
918 18th STREET
HOOD RIVER, OREGON 97031
PHONE (503) 386-6323

November, 10, 1988

000021

To: Roger M. Ogden

Subject: Spruce Budworm Project

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In conclusion, the only viable alternative that the U.S.F.S. has that is a sound and reasonable professional forestry and social decision is to use carbaryl and where necessary use b.t. Thank-you.

Sincerely,

FORESTRY DEPARTMENT
KENNETH GALLOWAY, JR.
FOREST MANAGER
918 18th STREET
HOOD RIVER, OREGON 97031
PHONE (503) 386-6323

November, 10, 1988

000022

To: Roger M. Ogden

Subject: Spruce Budworm Project

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In conclusion, the only viable alternative that the U.S.F.S. has that is a sound and reasonable professional forestry and social decision is to use carbaryl and where necessary use b.t. Thank-you.

Sincerely,

Dennis Keith Zacha

FORESTRY DEPARTMENT

KENNETH GALLOWAY, JR.
FOREST MANAGER

918 18th STREET
HOOD RIVER, OREGON 97031

PHONE. (503) 386-6323

November, 10, 1988

000023

To: Roger M. Ogden

Subject: Spruce Budworm Project

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In conclusion, the only viable alternative that the U.S.F.S. has that is a sound and reasonable professional forestry and social decision is to use carbaryl and where necessary use b.t. Thank-you.

Sincerely,

HOOD RIVER COUNTY

FRUIT RECREATION INDUSTRY

FORESTRY DEPARTMENT

KENNETH GALLOWAY, JR.
FOREST MANAGER

918 18th STREET
HOOD RIVER, OREGON 97031

PHONE (503) 386-6323

November, 10, 1988

000024

To: Roger M. Ogden

Subject: Spruce Budworm Project

Dear Sir:

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In conclusion, the only viable alternative that the U.S.F.S. has that is a sound and reasonable professional forestry and social decision is to use carbaryl and where necessary use b.t. Thank-you.

Sincerely,

RECEIVED
NOV - 8 1988

11-2-88

000025

Dear Forest Supervisor

I feel strongly that the U.S. National Forest Service should not spray (or apply in any other manner) Sevin or any other herbicides on our national forests to control the spruce budworm or any other pests. Sevin and other herbicides are ineffective, costly to apply, and harmful to the environment and the health of the people and animals who use the National Forests.

The Forest Service should investigate biological controls and other means of controlling pests, disease, and unwanted vegetation on our national Forests. A poisoned environment free of spruce budworm is a bad deal, even if Sevin were effective. Please enter my comments in the written record for this public comment process. Thank you

Sincerely,
Michael Cooper

Michael Cooper
P.O. Box 581
Veneta, OR 97485

HALF-BAKED ENTERPRISES

000026

~~930000~~

RECEIVED

~~RECEIVED~~

NOV 23 1988

Mail P.O. Box 910
JPS. Route 1 Box 148A
Halfway, Oregon 97834
503/742-4115

November 12, 1988

RECEIVED

James F. Torrence
Regional Forester
Forest Service Region 6
319 SW Pine
Portland, Oregon
97208

Re: Comment - DEIS on Spruce Budworm

Sirs:

I have now had a chance to study and consider the DEIS in some detail.

My conclusions are colored by my perception of history. It appears to me that man has often thought that he knew better than nature, only to find, too late, that that was not the case. The most famous historical example is the development of the Sahara desert. With that as background, then, I am inclined to search out the alternative with the least long term risk to the resource and the environment. Where that choice conflicts with short term needs, the decision must be based on a judgment as to relative risks and certainties, in the light of current knowledge.

On page IV-28, "The long term effect of protecting foliage would result in the maintenance of a forest with tree species susceptible to continued defoliation."

This suggests that the least risk is no action. There might be short term costs as the forest ecosystem readjusts, but long term results would be better for our descendants. In the very short term, there might be increased timber production from salvage operations, but the ultimate goal of a healthy and productive forest would stand an excellent chance of being accomplished.

Further, I believe it can be shown that budworm infestations occur where the forest is already somewhat unhealthy. Strong, properly spaced trees do an excellent job of encouraging predators and throwing off population explosions. The bug can, then, be viewed as part of a feedback mechanism designed to enhance the over-all vigor and health of the forest.

Finally, suppression methods based on spraying either BT or Carbaryl are expensive. I doubt that the cost can be economically justified, particularly considering that so many sales are now "below cost" as a result of efforts to reach non-sustainable harvest goals.

In summary, I would rank my preferences in the following order:

1. No action - as at present -- alternative A
2. occasional use of BT -- alternative B

Thank you for considering my input.

Sincerely,

Anthony Sowers

Anthony Sowers

Douglas Timber Operators, Inc.

3000 Stewart Parkway, Suite No. 208 • Roseburg, Oregon 97470 • (503) 672-0757

RECEIVED

NOV 23 1988

November 17, 1988

James F. Torrence, Regional Forester
USDA Forest Service
PO Box 3623
Portland, OR 97208

000027

Dear Jim:

Douglas Timber Operators, Inc., would like to take this opportunity to comment on the DEIS for Managing the Western Spruce Budworm in Oregon and Washington. DTO is an association of 80 logging, transportation, manufacturing, and supportive firms in Douglas and Coos County's.

DTO has supported sound, environmentally responsible, and intensive management for the last 25 years. DTO will continue this tradition by supporting utilizing all management efforts available in suppressing the current and future Spruce Budworm infestations.

DTO urges you to select the alternative that maximizes the agencies ability to suppress the Spruce Budworm. This should include a full battery of chemical, biological, and mechanical methods. DTO hopes you will select the alternative allowing the Forest Service to use any of these methods.

The Forest Service should consider a wide number of issues in considering which method to use. These should include the most economically efficient method, the method that has the highest probability of success, and the method which will do the best job in maintaining the highest longterm wood fiber production.

Of the alternatives presented in the DEIS, DTO supports Alternative D. We feel this provides a wide variety of control measures, maintains longterm timber supply, and will be the most efficient in controlling the infestation.

Thank you for the opportunity to provide comment on the DEIS. If you have any questions on these comments please feel free to contact the DTO office.

Sincerely,
DOUGLAS TIMBER OPERATORS, INC.

A. Troy Reinhart

A. Troy Reinhart
Executive Director

ATR/tcl

cc: DTO Board of Directors

ROSEBURG AREA
Chamber Of
Commerce

P.O. Box 1026

Roseburg, OR 97470

RECEIVED

NOV 23 1988

November 16, 1988

000028

James F. Torrence
Regional Forester
U. S. Forest Service
Pacific Northwest Region
P. O. Box 3623
Portland, OR 97208-3623

Re: Western Spruce Budworm DEIS, No. 3460

Dear Mr. Torrence:

The Roseburg Area Chamber of Commerce has taken an active interest in problems related to long-term timber supply. We believe timber supply is a statewide issue, with problems in one area impacting other areas.

Our Agriculture/Natural Resources Task Force has reviewed the above captioned document, and our Board of Directors has voted unanimously to support Alternative D.

We offer the following points in support of this recommendation:

- All infested areas should be treated, whether any damage is visible yet or not. With regard to "unacceptable damage", we believe any damage or potential damage is unacceptable.

- Since carbaryl is less expensive it should be used over most of the forest. Only sensitive areas such as stream buffers should be treated with B.t.

- Carbaryl should be more effective in some areas than B.t. due to the historically small window for effectiveness of B.t. Using both would assure maximum coverage.

- Carbaryl should always be applied at the full strength dose recommended. Half doses will not be as effective in killing the budworm, and could actually help build resistance.

- The Forest Service should continue to examine alternative pesticides since new chemicals will undoubtedly be available in the future. It would not be wise to lock in long-range efforts to control the budworm to the use of B.t. and carbaryl only.

We support the efforts of the Forest Service to control and eradicate, where possible, the western spruce budworm. For this reason and those listed above, we urge the Forest Service to adopt Alternative D. as its preferred alternative.

Sincerely,

Neal Walker

Neal Walker
President

cc Gov. Neil Goldschmidt
Senator Mark O. Hatfield
Senator Bob Packwood
Congressman Peter DeFazio
Congressman Les AuCoin
Congressman Bob Smith
Congressman Ron Wyden
Congressman Denny Smith

(503)672-2648

~~000000~~
C00030

November 21, 1988

NOV 30 1988

RESPONSE TO DEIS - MANAGEMENT OF WESTERN SPRUCE BUDWORM IN OREGON AND WASHINGTON

Having reviewed the DEIS for this project, I have the following concerns and observations I would offer for your consideration:

I felt that you gave inadequate consideration to silvicultural manipulation of the existing spruce-infected stands as a viable alternative. In reality, the current budworm outbreak can only be effectively controlled through silvicultural manipulation of these stands. Treating stands with bt is really a short-term "band-aid" solution to a problem that exists with the composition and exclusion of fire in these ecosystems. Application of bt may "cure" the current outbreak, but we can be fairly certain that another outbreak will occur if these stands are left in the condition they currently are in.

If we are really to get serious about an integrated pest management scheme, we need to get these stands back into a healthy, vigorous condition. In some cases, this may be impossible, given the current stand conditions. In those cases, harvesting of these stands should become top priority in the timber sale program. If stand manipulation techniques could be used to reduce the susceptibility of the stand to continued budworm attack (such as commercial thinnings, precommercial thinnings, etc.), these techniques should be used, and should be given high priority in planning and budgeting for those districts and forests where such stands exist.

Fire exclusion has certainly played a key role in the current insect outbreaks, particularly on the east side. Ponderosa pine or other appropriate pine species should be encouraged and planted wherever possible within these outbreak areas as they are harvested. Mixed species stands and multi-storied stands that currently exist need to be replaced with more fire-tolerant pine stands, if the ecosystem is to come back into a pre-fire suppression balance.

Fire could also be considered as a tool to help convert some of the current stands back into pine stands. In some cases, prescribed fires could be beneficial in replacing the current mixed species (that are low in fire resistance) with more fire-tolerant species, such as pine.

Many of these stands currently under attack from the budworm are not economical to harvest, and it may be necessary to use fire or other tools to destroy them and start anew with a vigorous young stand. The point is that this type of management must be <u>extensive</u> in nature; it does no good to treat only part of the infected area if conditions that would support re-infection are left untreated on adjacent areas. Some serious planning and thought needs to be given to dealing with these ecosystems on a <u>landscape</u> level, rather than on a forest, district, or other artificial boundary level. We must be willing to make some hard decisions that may adversely affect us in the short run, if we are to consider the long-range consequences of our management actions.

Stocking control of these stands is really a key issue. Money needs to be allocated to allow for reducing the stocking in those stands that could respond to such treatment. In those stands that are "too far gone" to respond to some type of thinning or stocking control, we should consider final harvest or stand destruction and replacement with a new, vigorous plantation of acceptable species. Fire should be prescribed where necessary to promote non-susceptible species.

In conclusion, I would again stress that in my opinion, a long-term goal of using silvicultural manipulation should be considered a viable alternative. It may not meet the immediate goal of budworm outbreak erradication, but I feel that the alternatives displayed in the DEIS do not meet this immediate goal.

Bill Dougan

Bill Dougan
Reforestation Specialist
Waldport Ranger District
Siuslaw National Forest

000031

11/26

POB 2962
Bellingham, WA 98227

RECEIVED
NOV 30 198?

W. Spruce Budworm Project

Dear Mr. Ogden-

In reviewing the Draft EIS for MWSB In OR+WA, I find the Forest Service to be up to its same old tricks. First, if budworms are native and natural, and the forests have functioned just fine for thousands of years, why change? Because there's an outbreak. Why is there an outbreak? Primarily because of fire management. Don't treat the symptom, don't spray chemicals all over the woods as another multi-industry subsidy -- let's return to natural fire cycles. I prefer Alt. A.

Second, if you must spray to satisfy innate budgetary and political incentives, why bother with carbaryl? Your analysis, especially relative effects on small mammals, birds and Insects, as well as potential for developed immunity, indicate clearly that B.t. is superior. I didn't find a cost comparison, but I assume carbaryl to be less expensive — how else is Alt. D justified? If so, I don't approve of passing the cost of industrial forestry on to "small mammals, birds and insects" who get a nice dose of petroleum products sprayed on them. Alt. B is better than D.

Sincerely - [signature]

RECEIVED

DEC 02 1988

November 25, 1977

3460
Mr. James F Torrence, Regional Director
319 S W.Pine St., P?O? Box 3623
Portland, OR 97208-3623

000032

Dear Sir:

Alternative B seems to be the best to myself and my friends. Biologival methods woule seem to be specific for the target pest but chemicals in the past have been ~~to~~ harmful to many forms of life and not solely against the targeted pest. Chemical co..panies likt many other businesses are mainly concerned with their profits and not concerned about tje total effects of their actions.

Yours truly, Ethel W Thornley

Ethel W Thornilery, 18653 Schoenherr, Det oit, MI, 48205

Please excuse the typing, I am legally blind.

F.S. RECEIVED 1988 STATE & PRIVATE FORESTRY R-S

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INIT | HTH | JSH | JDB | RDD | RGL | JPH | RAR | MGS | TVT | GRW | A F | CIH | ISG | KWM | FILE | TOSS

7TH Floor Support Group

Gary Larsen

KRB WS 2976
3905 Lakeshore
Moses Lake
WA 98837

To USFS Region 6 planners
P.O. Box 3623, PDX 97208-3623

000033 30 October 1988

Reply to 3460 – DEIS/Spruce budworm

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DEC 09 1988

RECEIVED R-6

Dear overworked planning staff!

If there can be no alternative using a combination of Indirect Suppression Using Silvicultural Techniques* combined with [project – specific] direct suppression with B.t. (Alternative B), THEN:

The only acceptable alternative is Alternative B.

Comment: DO NOT use carbaryl. This is a very poor idea. (Alternative D). The reasons not to use carbaryl are well documented in the DEIS summary. Use of this chemical insecticide poses unacceptable risks for cumulative impacts on plant community, wildlife,** water quality, worker health and other values.

I feel as if this has all been said before so many times that I wonder why carbaryl is even being considered, unless it's to make B.t. applications look good by comparison.

Please re-examine silvicultural methods for a long-term approach. Thanks very much for the chance to comment.

Sincerely,

Kris R Brotherton WS2976

Note: this is recycled paper, because I took it out of the DEIS summary.

---

* eliminated from detailed study, DEIS summary, p. 6

** caddisflies are important wildlife to trout, right?

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DEC 06 1988

Roger Ogden

James F. Torrence
Regional Forester
Pacific Northwest Region
USDA Forest Service
319 S.W. Pine P.O. Box 3623
Portland, Oregon 97208

RECEIVED
STATE & PRIVATE FORESTRY

November 21, 1988

Dear Mr. Torrence,

I have read and studied your Draft Environmental Impact Statement Summary - Management of Western Spruce Budworm in Oregon and Washington.

My preference for the management of the Western Spruce Budworm is your Alternative B. I am against the use of chemical insecticides in our forests and therefore reject Alternative D.

Here are some of my thoughts about the efficacy of Alternative B:

1. Alternative B seems to be the clear choice as I read through the comparison of alternatives (pp. 7-10). For instance, question two about effectiveness of treatment methods suggests that "resurgence and reinvasion are not anticipated" under alternative B, while under Alternative D "reinvasion need not occur; resurgence may occur."

2. Under question three, about effects of alternatives on other resources I read that "some resources such as general wildlife populations may benefit slightly" under Alternative B, while under Alternative D there may be "minor impacts to some resources."

3. Planning question Seven talks of future outbreak cycles and I see that under Alternative B the use of "B.t. should have no effect on future outbreaks,"

while Alternative D "may stimulate budworm populations and contribute to the resurgence of vigorous populations."

4. Finally, question eight discusses effects on human health and I see clearly that Alternative B gives us the best chance at avoiding health risks. Under Alternative D, I read of "intermediate" risks and reduced risks if "B.t. is used instead of carbaryl."

I am very concerned when I read that "carbaryl is very toxic to honey bees." (p.16) I keep bees and eat the honey they produce and do not like the thought of poisoning any honey bees.

I live a quarter mile from the Gifford Pinchot National Forest so I am a very concerned citizen when it comes to my backyard. In summary, I strongly urge you to select Alternative B to manage the current spruce budworm outbreak.

Sincerely,

Michael Hill
P.O. Box 323
Elbe, Wa. 98330

Curry Soil and Water Conservation District

POST OFFICE BOX 666 GOLD BEACH, OREGON 97444

December 8, 1988

Roger M. Ogden
Western Spruce Budworm
Project Leader
USDA Forest Service
Pacific Northwest Region
319 SW Pine, P.O. Box 3623
Portland, Oregon 97208

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DEC 13 1988

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Dear Mr. Ogden;

The Draft E.I.S. for managing Spruce Budworm in Oregon and Washington was reviewed by our Board of Directors. We appreciate the opportunity to comment.

We would like to be put on record as supporting Alternative "D". We feel that combined use of Biological and Chemical Controls may be necessary to abate the problem of Spruce Budworms. We do not like the idea of loosing an effective tool like Carbaryl. We applaude the option of using a relatively safe product as Bt. It is also important to us that the correct choice on a project-specific basis be made so that all resources are considered.

Thank You.

Sincerely,

Scott H. McKenzie

S. McKenzie, Chairman

CONSERVATION - DEVELOPMENT - SELF-GOVERNMENT

NEIL GOLDSCHMIDT
GOVERNOR

Oregon Department of Agriculture

635 CAPITOL STREET NE. SALEM, OREGON 97310-0110

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RECEIVED
DEC 12 1988

December 9, 1988

Rodger M. Ogden
Western Spruce Budworm Project Leader
USDA Forest Service
Pacific Northwest Region
PO Box 3623
PORTLAND OR 97208

Dear Mr. Ogden:

The Oregon Department of Agriculture is pleased to submit the following comments on the draft EIS for the proposed Western Spruce Budworm Project. Our comments and recommendations focus upon areas of concern we feel should be addressed in the final document.

Noxious Weed Control

The U.S. Forest Service Region 6 has a cooperative noxious weed control program with the Oregon Department of Agriculture, to control noxious weed species on Forest Service lands. A major emphasis of this integrated program is biological control of many of these weed species. The Department of Agriculture's concern with the Spruce Budworm Spray Project is with the impact on insects used in the biological weed control program. The spray formulation proposed for use is *Bacillus thuringiensis* (B.t.) and is specific to the Lepidoptera order (i.e., butterflies and moths). The only control agent that may be affected by B.t. would be the cinnabar moth *Tyria jacobae*, which is used as a control for the noxious weed, tansy ragwort. Distribution of the cinnabar moth is widespread throughout western Oregon.

The Department of Agriculture has been informed that a cooperative project between the Environmental Protection Agency and Oregon State University has demonstrated a 50% mortality to cinnabar larvae during bioassay experiments with B.t., at the rates used during spruce budworm control. Preliminary data shows that the first through third instars (i.e, growth stages) are most susceptible. Possible mitigating measures within delimited spray projects boundaries could include marking identified clearcuts where spray aircraft can shut off during application flights.

During the life of the Spruce Budworm Project, the Department of Agriculture should be informed of spray plans on and west of the crest of the Cascades, so that critical areas could be identified prior to spraying. This would help to minimize any adverse impacts to the cinnabar moth.

Threatened and Endangered Plant Species

The draft EIS, implies that the application of insecticides to be used in the suppression of spruce budworm will have a negligible impact on threatened, endangered, or sensitive plant species on USFS lands. This is a reasonable

assessment if B.t. and/or carbaryl are applied aerially. However, there are potential hazards associated with insecticide application in sensitive species habitat that are not adequately addressed. The most likely problem would be a reduction of insect pollinator populations, particularly species of butterflies, moths and bees. A second problem, although remote, would involve the burning of foliage after application (i.e., focused light).

If populations of any species deemed sensitive by the Forest Service are found to occur in spray areas, the Department of Agriculture would recommend that the following steps be taken: (1) determine if the species will be susceptible to burning due to leafing out or flowering during the scheduled application period, and (2) obtain information pertaining to the pollination requirements of the species. Such information might be obtained through consultations with the Department of Agriculture or the U.S. Fish & Wildlife Service.

As stated in chapter III, page 10, more than four hundred species currently on the Regional Forester's sensitive plant list are considered to be endangered, threatened, or sensitive by (among others) the State of Oregon. This statement is not completely accurate, and should be corrected. As provided under the Oregon Threatened and Endangered Species Act of 1987, the Department of Agriculture now has statutory authority for the listing and management of threatened and endangered species of the state. Prior to 1988, there was no official state list. Various private conservation groups in the state have prepared a species list which has largely been adopted by the Forest Service. However, this list has had no legal state sanctioning, and references implicating a state role should be deleted to avoid confusion.

In chapter IV, page 19, as listed under Threatened, Endangered, and Candidate Species, there is no Alternative C discussed. This alternative involves carbaryl application only, and a discussion of the environmental consequences to threatened, endangered, and sensitive plants species is important. Also addressed on this same page is the possible effect of insecticide application to annual plants with the implication that they alone would be apt to suffer reductions in seed set due to the elimination of pollinators. It is important not to discount the possible impact on perennial herbs as well.

In chapter IV, page 20, there is also no Alternative C discussed. This alternative involves carbaryl application only, and a discussion of the environmental consequences to fisheries and aquatic ecosystems is important.

In most of chapter IV, references cited in the text and summary are not listed in the bibliography-Appendix R. In fact, the bibliography contains only references dealing with pesticides. Also, references cited on page 1 of Appendix N are not listed. We recommend that a complete bibliography be included in the final document.

This concludes the Oregon Department of Agriculture's comments; we trust that these suggestions will be useful in the development of the final plan.

Sincerely,

W. H. Kosesan
Assistant Director
(503) 378-4665

[illegible]

Washington State
Department of Transportation
Transportation Building KF-01
Olympia, Washington 98504-5201
(206) 753-6005

000037

Duane Berentson
Secretary of Transportation

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DEC 1 1988

December 9, 1988

James F. Torrence, Regional Forester
Pacific Northwest Region
USDA Forest Service
319 SW Pine, P.O. Box 3623
Portland, Oregon 97208

Draft Envir. Impact Statement
Managing Western Spruce
Budworm In Oregon And
Washington

We have reviewed the Draft Environmental Impact Statement prepared by the Forest Service entitled Managing Western Spruce Budworm In Oregon And Washington, and support the selection of Alternative D as the preferred alternative.

Our primary concern, of course, is what impact the selected alternative may have on the hundreds of miles of State Highways within National Forest boundaries. Alternative D will provide more options for managing the problem with an acceptable level of risk, and result in less physical and visual damage to the forest.

Alternate A would result in severe defoliation of the forest. This would reduce the visual quality along the roadside. The visual quality of the highway corridor is important because it not only provides pleasure for the highway user, but enhances safety of the facility.

Alternatives B, C & D would rely on aerial application of insecticides. How would highway corridors be handled? Would they be treated during blanket spray applications or are they considered sensitive areas to be avoided? We believe the highway right of way should be treated with the remainder of the forest to prevent resurgence from an untreated area.

If the highway right of way is treated by aerial application it may be necessary to temporarily close the roadway to prevent spray drift on vehicles and avoid scaring motorists with the low flying aircraft. We would be happy to work with the Forest Service to coordinate the control effort.

Thank you for the opportunity to review this document.

Very truly yours,

Robert L. Berger

Robert L. Berger L.A.
Chief Landscape Architect
Operations & Maintenance

RLB
LHR:mac

cc: D. Lund

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DEC 16 1988

December 14, 1988

James F. Torrence, Regional Forester
USDA Forest Service
319 SW Pine, P.O. Box 3623
Portland, Oregon 97208

000038

Subject: DEIS Summary for Managing Western Spruce Budworm in Oregon and Washington.

Under, Effectiveness of Treatment Methods, page s-3, Only B.t. is discussed and the effectiveness of carbaryl is not mentioned. It is stated: "Treating too early can result in many individual larvae escaping exposure to B.t. because they are not feeding on folage that is exposed to spray." This implies that the larvae are not feeding on the succulent and tender needles at the branch tips, where the spray is most likely to fall, but are feeding on the older needles closer to the trunk. Where do the larvae really feed? If a larvae escapes the direct spray of carbaryl will it die from ingesting the sprayed folage? What effect does any spray, biological or chemical, have on the six instar stages or the pupae?

Under Planning Questions, page s-4, along with some of the questions the Forest Service has attempted to answer or give a discussion. Question #1. Spraying and thinning projects bring very few dollars into the local communities and the employment opportunities are near nil as most of this work is performed by contractors with their own crews. Any employment opportunity is short term and temporary. Question #2. What are the adverse impacts of carbaryl? Only B.t. is mentioned, why? Question #3. While there will be increased human disterbances to wildlife associated with control projects, the benefits from the insect control outweigh the adverse impacts to wildlife. Question #4. What is the effect of budworm treatment/non-treatment on scenic values and recreation use? The preparer went off on a tangent here as he only discussed wood fiber production. Why? Question #6. It must also be remembered that timber harvest and wildfire can have as much or more effect as does treatment or non-treatment does on hydrology.

The fact that the Forest Service chose two of four alternatives, B and D, as their preferred alternatives leads me to believe that it is difficult for them to make professional management decisions. If the Forest Service chooses Alternative B, they cannot use carbaryl, as is allowed in Alternative D. If the Forest Service chooses Alt. D which allows both B.t. and carbaryl, they do not need Alt. B. What is the rationale for choosing both alternatives?

Page s-6: Alternatives Considered in Detail. I believe this should have read, Alternatives Summerized. It is stated: Alt. B "..,with the objective of reducing budworm populations to nondamaging levels." Alt. C "The objective would be to reduce budworm populations to nondamaging levels for at least a major portion of the current outbreak." Alt. D has no objective listed. Why? What are nondamaging levels? Should your verbage have read, acceptable levels of damage? Nondamage means just that.

A one-swath untreated buffer strip, as mentioned in Alt. C, is highly ambiguous, and should be increased to two or more swaths. there are too many unknowns and uncontrollable factors for one-swath to have adequqte safety factors. Also it might be more economical to treat a wider buffer strip than to treat a one-swath strip.

There is no indication, in the DEIS summary, that an indepth study of the history of the western spruce budworm has been done by the Forest Service or any other entity. Do the capabilities exist to determine with certainty the size and intensity of past budworm outbreaks, in the Pacific northwest, over the past 100 years?

Pages s-7 thru s-10. Question #2, Alt. B states: "Resurgence and reinvasion are not anticipated." Yet under Alt. D it is stated: "Reinvasion need not occur; resurgence may occur." Both alternatives use B.t. Why the difference?

Question #3. Alt. A states: "Implementation of this alternative would not produce impacts to other resources." Yet Alt. A under Question #4 states: "...could result in decreased recreational use, with coresponding impact on recreation economy." Recreation is considered a resource, or the opportunity for recreation is considered a resource.

Question #5. I find it difficult to believe that short-term heavy fuel buildup could be eliminated under Alts. B,C, or D, with the use of B.t. and/or carbaryl. This implies that nothing but the western spruce budworm causes heavy fuel buildup. The speed of fireline construction is not dependent on whether the areas have been treated with B.t. or carbaryl as stated in Alts. B,C & D or non-treatment in Alt. A. Topography is the number one factor in determining or controlling the speed of fire line construction.

Question #6. Under Alt. A, what is considered a "significant increase" in annual streamflow or peak discharge? Why was extensive management activities included here? Extensive management activities by themselves could cause hydrological effects.

Question #7. Under Alt. B it is stated: "Earlier treatment would not have prented the 'spread' of budworm infestation. The application of B.t. should have no effect on future outbreaks." Earlier than what? Is the Forest Service goint to apply B.t. in an untimely manner? The above F.S. statement is contrary to Alt. B under Question #2; why? Under Alt. D why would the F.S. apply sublethal doses of carbaryl?

Question #8. Under Alt. C it is stated: "Carbaryl poses a human health risk only in the case of accidents." First, the DEIS summary does not list the components of carbaryl, both active and inactive including carriers. Second, unless so specified, when speaking of carbaryl it includes all components that would be sprayed for budworm control.

On page s-21 it is stated: "Unprotected workers who routinely apply carbaryl may experience some toxic effects from the kerosene-diesel oil mixture." What is the true risk from CARBARYL? Under Alt. D, what is a "human health risk of an intermediate nature? How is it measured?

Page s-12. Visual Resources. The visual qualities of the environment are very subjective and some of the so-called negative effects of natural agents are actually positive. After the eruption of Mt. St. Helens the visual resource visitor occurance increased many fold, for this area. Many will flock to Yellowstone National Park, in 1989, to see the awsome effects of the 1988 fires.

Page s-13. Social and Economic Conditions. If the first sentence of this topic is true, why are so many people from outside of the area so concerned? Do not the forest outputs in Oregon and Washington, which are affected by the spruce budworm, directly influence the posibility of the millions of first time home buyers of having a unit available?

Under Public Health, what hard evidence does the F.S. have that those people living near forest lands are any more concerned with environmental issues than those living elsewhere?

Mitigating Measures. "Aerial insecticide application near streams and open water is controlled by state law." State law sets forth the legal aspects of insecticide application. The operator or pilot of the plane or spray rig actually controls the application of the insecticide.

Page s-14. Vegetation. Under Alt. A states: "The no-action alternative over time would open pockets in the tree canopy due to mortality." Tree harvest, over time, under any alternative would also open pockets in the tree canopy, would it not?

Timber. When would suppression measures, for budworm, be used under Alternative A?

In column two near the top of the page, under Alternatives B,C and D is stated: "With the action alternatives, there would be very little budworm-caused mortality in the undamaged stands." Is this a staff consensus or an actual field observation?

Page s-15. Second paragraph, left column. What will bring about the proliferation of extensive areas of the preferred hosts?

Column two under Alt. C contains another ambiguous and confusing statement: "Reinvasion from untreated areas within the treatment areas is a potential problem." Any untreated area is outside of the treatment area, including the so-called buffer strip along streams. Your statement should have read; 'Reinvasion from untreated areas adjacent to the treatment areas is a potential problem.'

Under Alt. D, it is stated: " When there is no practical difference or no concern about potential effects..." Has the Forest Service thrown concern for potential effects to the wind and will use either carbaryl or B.t., at will, and the effects be-damned?

Pages s-15 & s-16. Wildlife. Alternative D was not discussee under this heading. Why? Does this mean that Alt. D is not a viable alternative as far as wildlife are concerned?

Under, Wildlife Risk Overview, it is stated: "Risks to wildlife are low to negligible in the spruce budworm suppression program." "Alternative C would not present a risk to wildlife." "Carbaryl is considered moderately toxic to mammals and slightly toxic to birds." "Carbaryl is very toxic to honey bees." All on the same page we find much confusion. What is the true effect of carbaryl on wildlife?

Page s-17. There is no Alt. C listed under Fisheries/Aquatic Ecosystems. Why? Also it is stated: "Carbaryl degrades rapidly in water in 1 to 5 days." What does carbaryl degrade into, elements etc? Does it actually degrade or does it just become diluted? Would not carbaryl's low solubility factor hinder it's degrading, in water, if in fact it degrades?

Can the Forest Service afford to use carbaryl when it has a stunting effect on conifer seedlings?

Page s-19. Hazard Analysis. What are the identified toxic properties of B.t. and other chemicals analyzed?

Under, Risk Analysis. What is the NOEL level in PPM that would equal a BM of 100?

Under, Carbaryl. What is considered as: "the absence of significant tumor incidence."? Who has to have the tumor for it to be significant, you, me or the rat?

Page s-20. If diesel oil is only "very slightly toxic, based on an acute oral dose", should it not be safe to bathe in?'

If the quality of data for carbaryl and B.t. are inadequate, how can the Forest Service consider using them?

Margins of Safety for Special Casw analysis. "....so there is little risk from runoff when large areas of a watershed are sprayed,..." Sprayed with what?

Page s-21. Risk to the Public in Accidents. Are these risks for carbaryl only or for all sprays?

Due to the uncertainties and lack of complete information on all sprays, I recommend that only B.t. be considered, as a spray, to suppress the spruce budworm.

I support and recommend Alternative B.

Sincerely,

Frank Vaughn
936 N 7th
Lakeview, Or. 97630

ELLINGSON
LUMBER CO.

P. O. BOX 866
BAKER, OREGON 97814
PHONE: 523-4404

000039

December 14, 1988

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DEC 1[illegible] 1988

James F. Torrence
Regional Forester
Pacific Northwest Region
P.O. Box 3623
Portland, OR 97208

RE: Draft Environmental Impact Statement for
Managing Western Spruce Budworm in Oregon and Washington

Dear Mr. Torrence:

Please accept my comments into the record concerning the above stated Environmental Impact Statement.

I would choose Alternative D. In actuality, I would change it slightly by stating that I would not preclude the use of any biological or chemical agent. It is my feeling that the hysteria that has been generated about the use of chemicals, in agriculture in particular, is overblown. I think that it is a travesty.

Thank you for the opportunity to comment.

Yours very truly,

ELLINGSON LUMBER CO.

G. Peter Ellingson
Division Manager

GPE/jah

cc: Roger M. Ogden

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DEC 19 1988

7640 S.E. 28 Ave.
Portland, OR 97202
December 14, 1988

Spruce Budeorm Program
USDA Forest Service, PNW Region
Portland, OR

Dear Mr. Bilyeu:

I have reviewed the DEIS Summary on Management of Western Spruce Budworm and offer the following comments.

This report is well written and strikes me as a careful and thorough study by professionals in this field. As a professional forester I would have no preference between either of the Preferred Alternatives B or D.

Editorial comments:

P. Summary--1. Heading Current Situation identifies infestation on East Side, but says nothing about the West Side. Isn't some of the infestation on the West Side?

P. Summary--3. B.t. should be spelled out first time used. It would be awkward to do this under "Economics" rather than under "Effectiveness of Treatment Methods," so I'd recommend interchanging these two sections (Also change order of listing at bottom of p. 2).

P. Summary--5. Under USDA goals, I would prefer changing adequate to an abundant supply. . ., but check USDA regulations to see how they state this.

Sincerely yours,

Thomas C. Adams

Thomas C. Adams,
Professional Forester
USDA-Forest Serv.--PNW (Ret.)

LONGVIEW FIBRE COMPANY

MAIN OFFICE AND MILLS LONGVIEW, WASHINGTON 98632
1-206-425-1550

December 15, 1988

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DEC 19 1988

Mr. Roger M. Ogden
USDA Forest Service
P.O. Box 3523
Portland, Oregon 97208

Dear Mr. Odgen,

I generally support the findings in the DEIS on Western budworm management.

There are, however, some indications of a bias against treatment with carbaryl and possibly against any treatment. For example; in planning question #2 resurgence and reinvasion are not anticipated when using B.T. but in alternative D (carbaryl and B.T.), reinvasion need not occur; resurgence may occur. I do not believe this gives an accurate picture.

As for the development of carbaryl resistand budworm, it does not appear that enough of a case has been made to bring this possibility to such importance that it is part of an answer to one of only eight questions.

The effectiveness of carbaryl through a longer portion of the budworm life cycle, the fact that it is effective through contact, and the somewhat longer period of effectiveness after application combines to make it a more effective insecticide. There are also other factors which tend to make carbaryl more likely to be effective under a wider range of conditions. It also appears to be a very safe insecticide to use and has only temporary and minor side effects in the environment.

Alternative D is definitely the best alternative, but B.T. should be used only where absolutely needed; around class I streams, open water, residences, etc.

Yours Truly,

Stan Benson
Asst. Tree Farm Mgr.

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DEC 19 1988

December 15, 1988

Mr. Roger M. Ogden
Western Spruce Budworm Project Leader
USDA Forest Service
Pacific Northwest Region
319 Southwest Pine
P. O. Box 3623
Portland, OR 97208

Dear Mr. Ogden:

The following comments relate to the Draft - EIS on Managing Western Spruce Budworm.

I support Alternative D and trust U.S. Forest Service judgement in the proper application of Carbaryl along with B.t. While B.t. has proven itself, Carbaryl, also proven, adds a tool giving broader timing, consistency and lower cost that outweight some of the advantages of B.t.

I am surprised that the Draft EIS does not include a discussion of mortality salvage and alternate conifer species as part of an integrated pest management program.

Sincerely,

Jim Clarke

Jim Clarke
1901 Heritage Hills
North Bend, OR 97459

JC:51/4a/1

Reply to: 1922 Willamette, Eugene, OR 97405

SIERRA CLUB
Oregon Chapter

000043

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DEC 2 - 1988

December 18, 1988

James F. Torrence
Regional Forester
Pacific Northwest Region
U.S. Forest Service
319 SW Pine
Portland, OR 97208

Re:DEIS on Managing Western Spruce Budworn in Oregon and Washington

Dear Mr. Torrence:

In response to the above-captioned Draft Environmental Impact Statement, the Oregon Chapter of the Sierra Club respectfully requests that the U.S. Forest Service prepare a supplemental environmental impact statement to outline how the agency plans to fulfill its stated commitment (Chapter I - 3) to become capable of making long-term strategic decisions for management of insect pests.

In our view, the DEIS begs the question by limiting the scope of the decision to "dealing with the question of what should be the strategy for managing the current outbreak." The document appears to postpone to some hoped-for future a real examination of the long-term issues of integrated pest management in Region 6 forest lands.

I recently attended a public meeting at the Region 6 headquarters on responding to the DEIS. At that time agency officials repeatedly stated that the time and place for dealing with long-term issues of any kind is the national forest plans. However, the draft national forest plans do not appear to address long-range pest management to any meaningful degree. Furthermore, it is unclear how the regional EIS on vegetation management will be integrated with the final national forest plans. In short, integrated pest management appears to be languishing in some sort of twilight realm between forest planning, vegetation management planning, and direct suppression.

If the Forest Service is to live up to its stated commitment to have the operational capability within 5 years to implement long-term pest management strategies, then the agency should spell

out for the public: 1) what research it is doing to acquire the base-line data needed to make this possible; 2) how it is already implementing, as officials stated at the meeting, the silvicultural and burning practices "seen as a lasting solution to management of spruce budworm outbreaks; and 3) what operational changes it has planned to make integrated pest management a reality on national forest lands.

It would appear that a supplemental EIS would go a long way toward putting this information before the public. A reluctance to do so would encourage the perception that the agency's actual movement toward long-term solutions is more conventional than real.

In the agency's "Forest Insect & Disease Leaflet 53," which James Hadfield distributed at the recent meeting on the DEIS, reference is made to a spruce budworm epidemic in the Rocky Mountains which has persisted since 1949 "in spite of repeated insecticidal treatment between 1952 and 1966 of more than 6,000,000 acres (2,430,000 ha) of forests." No doubt the land managers in that situation were confident that the strategy of "managing the current outbreak" would suffice. Clearly it did not, and the agency has since realized the need for long-term strategies. At the same time, agency officials admit that the research budget earmarked for spruce budworm research is inadequate to produce data needed to plan long-term solutions to the massive infestations of this insect pest. This leaves the public understandably skeptical of the agency's capability of planning and realizing integrated pest management for this or any other major forest pest.

We would like to see lobbying by the agency stepped up to acquire research funding not only for spruce budworm studies but studies of other insect pests likely to remain endemic in the region's ecosystem.

As for the alternatives arrayed in the DEIS, agency personnel have admitted privately that Alternatives A and C are politically impossible in Oregon, leaving only B and D as practicable. However, by endorsing both of them as "preferred," the agency is, in effect, endorsing neither. Is not the preferred alternative supposed to let the public know what the collective wisdom of the agency is? As with the recent vegetation management EIS, it would appear that the spruce budworm DEIS takes no position other than to reflect what regional politics will allow.

Equally troubling is an apparent internal contradiction in descriptions of Alternative D. In Chapter II -3, the implication is that carbaryl would be used as a supplement to the use of B.t.

with the proviso that "The choice of carbaryl or B.t. over the majority of the treatment area would be determined on a project-specific basis." However, in Chapter IV - 18, the document states, "It is assumed B.t. will be applied on sensitive areas, e.g., riparian/watershed, and carbaryl will be used on all other areas." Depending on the parameters used to define sensitive areas, this could mean a far greater application of carbaryl than the public might infer from reading the description in Chapter II. Certainly this needs clarification.

Of the so-called preferred alternatives, clearly the B.t.-only strategy is less harmfully environmentally. However, we feel that the DEIS overstates the harmlessness of wholesale applications of the biological insecticide. It is clear from research overlooked by your consultants that B.t. can dramatically supp ress populations of non-targeted Lepidopterans, for example.

If the Oregon Chapter were to endorse any of the four alternatives presented, it would be Alternative B on the grounds that it is the least ecologically destructive action alternative for immediate control of spruce budworm in the region. However, we feel that the DEIS reflects an ongoing tendency of public agencies to continue postponing the implementation of integrated pest management. For this reason, we close by reiterating our request for a supplemental EIS on agency planning for integrated pest management of the spruce budworm.

Sincerely,

Teresa Carp

Teresa Carp
Pesticides Coordinator
Oregon Chapter
Sierra Club

cc: Roger Ogden
Hon. Mark Hatfield
Hon. Les AuCoin
Hon. Bob Packwood
Hon. Peter DeFazio

American Fisheries Society
Oregon Chapter
P.O. Box 722
Corvallis, Oregon 97339

REC[illegible]D
DEC [illegible]

000044

December 12, 1988

Mr. James F. Torrence
Pacific Northwest Region
3119 SW Pine, Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

The Oregon Chapter of the American Fisheries Society is pleased to comment on the Final Draft Environmental Impact Statement (DEIS), "Management of Western Spruce Budworm in Oregon and Washington." We have reviewed your Draft Environmental Impact Statement of October 17, 1988 and make the following comments:

We recommend your Preferred Alternative B. We do not feel that the risk of using a broad spectrum organic insecticide, such as carbaryl, is warranted now that the "safe" effective alternative *Bacillus thuringiensis* (*B.t.*) is available.

We feel that alternatives using organic insecticides should no longer be considered because:

1. The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of an even more vigorous population.

2. Target insect populations are likely to develop a tolerance to an organic insecticide.

3. The one-swath wide buffer strip will not protect the stream because of the effects of slope, updrafts, and errors in aerial application. Even though carbaryl will not kill the resident fish at application levels, amounts in the water as low as 5 ug/l (5 parts per billion) can disrupt and destroy the invertebrate food base for these animals.

4. One of the biggest problems with organic pesticides is from accidental spills. This was clearly demonstrated during the U.S. Forest Service's 1983 Spruce Budworm Spray Project. During that project a number of major spills occurred, one in particular destroyed 27 miles of stream fauna in Willow Creek. By eliminating these chemicals from forest use the risk from accidents will also be eliminated.

5. The DEIS does not address long term management solutions for managing forests subjected to large scale spruce budworm infestations. Spray programs are short term solutions only.

6. Integrated Pest Management strategies are not discussed.

7. The Forest Service has found *B.t.* to be a very effective pesticide for controlling the spruce budworm. It does not follow that the use of carbaryl is a preferred alternative.

Even though we accept Alternative B we feel that more work needs to be done to determine the safety of *B.t.* to aquatic organisms. Very little research has been carried out in testing this agent on stream animals. The Forest Service should take the lead in demonstrating to the public that this control method is safe to non-target organisms.

We hope you seriously consider our comments. We are available to offer our assistance in further planning. Please send a copy of the final draft of the DEIS.

Sincerely,

Krystyna Wolniakowski

Krystyna Wolniakowski
President, Oregon Chapter AFS

PRAIRIE WOOD PRODUCTS
P. O. Box 66 • Riddle, Oregon 97469 • (503) 820-3351
(503) 874-2231

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DEC - 1988

December 14, 1988

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DEC 21 1988

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James Torrence
Regional Forester
Pacific NW Region
319 SW Pine
P. O. Box 3623
Portland, OR 97208

RE: DEIS MANAGING WESTERN SPRUCE BUDWORM IN OREGON AND WASHINGTON

Dear Mr. Torrence:

On behalf of Prairie Wood Products I would like to express our appreciation for the fine effort the Forest Service has made in addressing the Spruce Budworm problem in this DEIS. It is our position that insect and disease control in Oregon has not received the proper attention over the last few decades and as a result we are now seeing the adverse results. This DEIS is hopefully a turning point.

Prairie Wood Products believes very strongly that a combination of spray techniques should be available for the land manager. Therefore we are very pleased to see this philosophy adopted in the DEIS. However, in addressing the budworm problem we must also keep in mind that a spray program is only a short term solution. The long term solution will require an agressive program of host species management. A long term management program should be developed and set forth in both this DEIS and the upcoming forest plans. (Currently the long term management program of stocking level controls is grossly underfunded. It is imperative that the stocking level control programs be given a priority and the proper funding.)

Host species management is a concern not only for budworm control but also is important for the control of the Mountain Pine Beetle. The need for a forest management program is again being demonstrated on the Malheur National Forest. On the Malheur National Forest we are now starting to see the first signs of a new Mountain Pine Beetle infestation. An infestation which is best controlled through proper vegetative management of the ponderosa pine stands. Rather than sitting back and watching this attack run its course we must act aggressively now by implementing and funding a thinning program.

Vegetative management is the long term solution to both the budworm and Mountain Pine Beetle infestations.

As a final comment we would like to note that as the budworm starts to decline we can anticipate secondary attacks by other insects and diseases. To address these potential infestations we need to develop a strategy to monitor and contain any secondary attacks. To avoid unneccessary delays and appeals this strategy should be a part of this DEIS. We are already experiencing both the secondary attacks and appeals on the Wallowa Whitman National Forest.

Thank you for this opportunity to comment.

Sincerely,

Ron Yockim

Ronald S. Yockim
Corporate Counsel

RSy/sb

cc: Senator Mark Hatfield
Senator Bob Packwood
Representative Bob Smith

WESTERN FOREST INDUSTRIES ASSOCIATION
1500 S. W. TAYLOR STREET · PORTLAND, OREGON 97205
TELEPHONE
503-224-5455

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Mr James F Torrence
Regional Forester, R-6
U.S. Forest Service
Post Office Box 3623
Portland, Oregon 97208

12/19/88

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Dear Mr Torrence;

Please consider this letter as Western Forest Industries associations response to your Draft Environmental Impact Statement for managing the Western Spruce Budworm in Oregon and Washington.

In our opinion ALTERNATIVE D is our choice for the preferred alternative to be applied on all National Forest lands and adjoining lands, where explicable, when Western Spruce Budworm is becoming prevalent.

Alternative D provides site specific adaptability for the proper practice of silvicultural management. However, from information gather by us from knowledgeable scientific individuals, it appears that your mentioning of the application rate of carbaryl to be 0.5 lbs a.i. per acre, maybe be contrary to the manufacture's recommendations and also from the best historical findings on past applications. If upon further review this is indeed true, then your correction to the Final would be appreciated.

We agree with your analysis that this document is sufficient to meet the requirements of all federal regulations and that your agencies progress on this matter needs to be expedited. It is this offices opinion that any prolonging of the final decision to modify or supplement the DEIS will have limited beneficial results on any silvicultural practices that are found to be needed on the Forest in the near future.

Thank you for this opportunity to respond to this DEIS document.

Very Truly Yours;

Bob Pfatz, Forester
Western Forest Industries Association
2608 Pacific Ave.
Olympia, Washington 98501

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DEC 21 1988
Regional Forester

NEIL GOLDSCHMIDT
GOVERNOR

Forestry Department
OFFICE OF STATE FORESTER
2600 STATE STREET, SALEM, OREGON 97310 PHONE 378-2560

2-0-8-210
2-1-1-321

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DEC 21 1988

December 20, 1988

000047

Mr. Roger M. Ogden
Western Spruce Budworm Project Leader
USDA Forest Service
P.O. Box 3623
Portland, OR 97208

Dear Roger,

Our comments concerning the DEIS on Management of the Western Spruce Budworm in Oregon and Washington are enclosed. They have been organized under different topics and referenced to the documents.

We appreciate the summary publication. It is very useful to us and surely other reviewers.

If you have any questions about our comments, please contact me (378-2554) or Dave Overhulser (378-2218).

Sincerely,

LeRoy Kline

LeRoy N. Kline, Director
Insect & Disease Program

LNK/lle
Enclosure
OGDEN.0
cc: Bill Ciesla

Oregon State Department of Forestry Comments DEIS - 1988, Management of Western Spruce Budworm in Oregon and Washington

Objectives Used in Designing Alternatives

Summary - 6

All objectives deal with environmental issues, driven by concerns of the environmental community. None deal with the concerns of the timber industry and adjacent non-federal landowners. Objectives dealing with timber supply, and effectiveness of each alternative needs to be added.

Summary - 23, Unavoidable Adverse Effects

The summary states, "Because the EIS examines alternative methods for managing western spruce budworm outbreaks, the focus is on how the different methods could affect the environment."

We feel that the focus should also be upon the effectiveness of protecting forest resource values. This is just as important as the adverse effects when making a decision.

Alternatives

Perhaps we don't understand the DEIS process or the linkage between the FEIS and the EA. It appears to us that a fifth alternative may be needed for consideration. That being a combination of no-action (in some areas) and action (in other areas). There has been and always will be areas in which no-action is taken for many reasons.

Alternative A (no-action)

All issues seem to be addressed; however, we do not necessarily feel that "... over time, would open pockets in the tree canopy due to mortality. The cumulative effect of this alternative would be a gradual change of stand structure over time." (Summary - 14). If the present methods of stand management and fire exclusion continues, we doubt that stand structure will change over time.

Alternative B (B.t. only)

In regards to this alternative, as well as C and D, the statement that ". . . long-term supply of wood fiber will be maintained . . ." (Summary - 7) is not entirely correct. Because of lack of control in the mid-80's, many opportunities to protect the resources have been lost. Damage has been done and that will affect timber supply in some areas in the future.

Regarding the statement with B.t. that ". . . resurgence and reinvasion are not anticipated." (Summary - 7). We do not feel there is data to support that statement. It's going to depend upon the phase of the outbreak when treatment takes place, pre- and post-spray insect populations levels, etc.

Concerning "Some resources such as general wildlife populations, may benefit slightly." (Summary - 7). Reducing lepidopterous insects that are food to song birds could effect their populations.

We agree that this alternative probably "presents the least risk of the direct suppression alternatives" and is more politically and socially acceptable on public lands. It may or may not be the case on private lands.

Alternative C (carbaryl only)

In regards to ". . . resurgence is a potential problem." (Summary - 7). Resurgence should be less of a problem than with B.t. because of generally being able to reduce populations lower. Again, much depends upon the phase of the outbreak, pre-spray populations, weather, applications, etc.

The document seems to be more bias for B.t. and against carbaryl. The political process should deal with this, not the EIS.

All in all, a reasonably good job in addressing the issues.

Alternative D (B.t. and carbaryl)

Again, the concern about "resurgence may occur" (Summary - 7). With this combination, resurgence and reinvasion should be less than the other alternatives.

Concerning the statement "The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of vigorous populations." (Summary - 9). Sublethal dosages of any insecticide could

have this result; and the possibility of it happening is greater with biological insecticides.

USDA Forest Service Goals

Summary - 1, Introduction, last paragraph.

What ownership base does or should the DEIS cover? The document states, "The final version will be the basis for selection of a program for managing future western spruce budworm infestations in National Forests in the PNW."

Summary - 1, Decision Needed, first paragraph.

The document states, "The decision needed in this EIS is how to manage the current spruce budworm outbreak. . . . Four alternative programs were developed for managing the current outbreak of the WSBW on lands administered by the USFS, BLM, BIA, and State and private lands in Oregon and Washington."

Clarification is needed as to whether this document and process addresses the future or current problem; or both.

We do not feel that the NEPA process should be addressing and determining what should be done on non-federal lands. We understand that constraints can be placed on actions on non-federal lands if federal funds are involved. This distinction should be clarified in the document.

Summary - 5, Forest Service Goals, first paragraph.

The document states, "These objectives are attained on non-federal lands through cooperation with State Foresters."

We recommend the word "are" be changed to "may"; and in the last sentence, "private lands" be changed to "non-federal lands".

We feel it is the right of the non-federal owners and managers to determine what should be done on their lands.

Major Issue and Concerns Sections

The eight "public" issues identified in the document (Summary - 2) reflects more environmental concerns than the impact of the budworm upon timber supply. Possible reductions in National Forest timber harvest levels should be a major

heading. The timber supply issue should not be hidden under the Economics Section.

Treatment History

Appendix N-2, Column 1, fourth paragraph.

In regards to the 1988 Boise Cascade project in Oregon, "rumors are that results were excellent". The NEPA process should not deal with rumors, but facts and data as much as possible. We suggest you contact the company and ask permission to use their data.

Appendix N-2, Column 2, first paragraph.

The document states, "From the preceding it is apparent that under the conditions of these projects, there is no practical difference in the short-term population reduction efficacy of carbaryl or B.t.; both can reduce populations to less than 1 larva/45 cm branch tip given proper application and project administration." The 1988 federal and private projects data shows that this is not necessarily true. Early larval densities and where we are in the outbreak phase are also important in relationship to insecticide effectiveness. Check the Meacham Pilot project data; some formulations of B.t. did not meet the post-treatment criteria.

Appendix N-2, general.

In regards to the history of treatments in Oregon since 1982, we are disturbed by the "on and off" of projects. One year, hundreds of thousands of acres are treated, and the next year none or very little are treated. Earlier in the outbreak (1983-1984) it was not economical or justifiable to treat the Mt. Hood and Wallowa-Whitman National Forests! Now after much damage and declining populations, these areas are treated or proposed to be treated. We understand the reasons behind some of this. However, many private landowners and the public do not. Our credibility suffers. We should not mislead the public into thinking that the NEPA process is always based upon technical data and material. The decision is usually political, either from outside pressures or changes in landowners or managers.

Effectiveness of Treatment Methods

Summary - 3 and throughout the main document.

As much discussion and data should go into the effectiveness of treatment methods as was done in the environmental

consequences of treatments. Selection of a treatment method is based upon many factors:

1. Immediate reduction of budworm populations.
2. Long-term reduction of budworm populations.
3. Short-term protection of the foliage.
4. Long-term protection of the timber in terms of growth and yield.
5. Visuals.
6. Operational feasibility and efficiency.
7. Economic.
8. Natural enemies of the budworm.
9. Animals, fish, birds.
10. Human health.
11. Water.
12. Pre-spray larval populations.
13. Phase of the outbreak.
14. etc.

Perhaps the planning questions for each alternative needs to be expanded.

Resurgence

Chapter IV - 8, 9, & 10; and Summary - 7 - 10 (Comparison of Alternatives)

The discussions throughout on resurgence of budworm populations after treatments is strongly biased in favor of B.t.. Why? Where is the data after almost a decade of treatments? The potential for resurgence and reinvasion, based upon our experiences in Oregon over the past six years, appear to be more of a problem in the early years of the outbreak. The key factor is pre- and post-spray larval populations with each respective insecticide. The statement that resurgence is not expected to be a problem with B.t., because sublethal doses do not stimulate vigorous populations is unproven, and in our opinion, untrue. If B.t., or any insecticide, does not kill significant numbers of larvae, populations will likely resurge.

Growth Loss

Chapter IV - 5, Column 2, paragraph 4.

The impact section does not cite the following pertinent publication:

Alfaro, Rene I. 1986. "Mortality and Top-Kill in Douglas-fir Following Defoliation by the Western Spruce Budworm in British Columbia". J. Entomol. Soc. Brit., Columbia 83, Dec. 31, 1986.

Chapter IV - 5, Columns 1 & 2.

There is no mention of how the severity of budworm impacts differ with uneven and even age stand management.

Chapter IV - 5, Column 2, paragraph 6.
Chapter IV - 6, Column 1, paragraph 1.

The ability of non-host conifers to make-up growth losses in host conifers is over emphasized. Most severely impacted stands do not have a significant non-host component. This is particularly the case in the Cascades and parts of northeast Oregon. It is also untrue that host trees will be replaced over time by more resistant species. If stands receive uneven age management and fire exclusion, stand composition will remain much the same.

<u>Wilderness</u>

Summary - 18

The document states, "The life cycle of the western spruce budworm suggests the lack of treatment in wilderness does not pose a threat to non-wilderness adjacent lands." We don't understand this statement at all! In the second column under alternatives B, C, and D, it says, "Insecticide application would interfere with the natural processes which are a key part of the wilderness resource." This is the true reason why treatment may not be done in the wilderness; not the "life cycle" of the insect.

<u>Citations</u>

All citations in Chapter IV and Appendix N in the main document should be checked to make sure they appear in the Bibliography (Appendix R). Several that did not appear include:

Citation	Page	Column	Paragraph
Alfaro, et al 1982	IV-5	2	1
Crimp, 1982	IV-5	2	1

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Dec. 19, 1988

Roger Ogden
Western Spruce Budworm Project Leader
USDA Forest Service
P.O. Box 3623
Portland, OR 97208

Dear Mr. Ogden:

I would like to comment on the DEIS for Managing Western Spruce Budworm in Washington and Oregon. I am a professional forester with 15 years experience in the field and have been involved in two budworm control projects. I was involved in the 1983 Sevin and Bt project around John Day and the 1988 Bt project in Oregon.

I urge the US Forest Service to adopt alternative D for many reasons, primarily due to the flexibility two proven insecticides, carbaryl and Bt give to a control program. Carbaryl has been demonstrated as a lower cost tool and with greater efficacy than Bt. As a taxpayer, that combination is very appealing to me! Your data shows that carbaryl is neither oncogenic or mutagenic.

Bt has been shown to be effective, yet not as efficatious ... a smaller time frame in which it is effective relative to the larval development and much more costly then carbaryl.

In 1988, Hood River County and Longview Fibre Company completed a 40,000 acre project using primarily carbaryl for a cost of between $11 and $12 per acre. That figure includes, pesticide, application, entomology pre and post work, and supervision costs. So far, the only figure I can get is about $25 per acre for the 1988 Oregon Spruce Budworm project using only Bt.

The need to control outbreaks of the Budworm is great in terms of keeping the forests healthy. Healthy forests benefit man by keeping wood fibre production high for value as wood products in a sustainable harvest program. The no action plan would devastate the economies (long term) of many communities dependent upon the woods products industry.

Healthy forests also reduce fuel loading problems and therefore reduce the chance of catastrophic fires which can occur in areas of heavy insect defoliation and mortality. The Paulina Lakes fire in 1988 near Bend in Pine Beetle killed stands shows the

danger of high fuel loading!

In conclusion, I support the adoption of Alternative D, using Carbaryl and Bt to achieve the best budworm control at the most cost effective methods in order to maintain a healthy, economically productive forest for all people in the Pacific Northwest.

Sincerely yours,

B P. Alber

Bruce P. Alber
6195 Thurston Rd
Springfield, OR 97478

... 1511 Willamette, Eugene, OR 97403

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SIERRA CLUB
Oregon Chapter

December 18, 1988

James F. Torrence
Regional Forester
Pacific Northwest Region
U.S. Forest Service
319 SW Pine
Portland, OR 97208

Re:DEIS on Managing Western Spruce Budworn in Oregon and Washington

Dear Mr. Torrence:

In response to the above-captioned Draft Environmental Impact Statement, the Oregon Chapter of the Sierra Club respectfully requests that the U.S. Forest Service prepare a supplemental environmental impact statement to outline how the agency plans to fulfill its stated commitment (Chapter I - 3) to become capable of making long-term strategic decisions for management of insect pests.

In our view, the DEIS begs the question by limiting the scope of the decision to "dealing with the question of what should be the strategy for managing the current outbreak." The document appears to postpone to some hoped-for future a real examination of the long-term issues of integrated pest management in Region 6 forest lands.

I recently attended a public meeting at the Region 6 headquarters on responding to the DEIS. At that time agency officials repeatedly stated that the time and place for dealing with long-term issues of any kind is the national forest plans. However, the draft national forest plans do not appear to address long-range pest management to any meaningful degree. Furthermore, it is unclear how the regional EIS on vegetation management will be integrated with the final national forest plans. In short, integrated pest management appears to be languishing in some sort of twilight realm between forest planning, vegetation management planning, and direct suppression.

If the Forest Service is to live up to its stated commitment to have the operational capability within 5 years to implement long-term pest management strategies, then the agency should spell

out for the public: 1) what research it is doing to acquire the base-line data needed to make this possible; 2) how it is already implementing, as officials stated at the meeting, the silvicultural and burning practices "seen as a lasting solution to management of spruce budworm outbreaks; and 3) what operational changes it has planned to make integrated pest management a reality on national forest lands.

It would appear that a supplemental EIS would go a long way toward putting this information before the public. A reluctance to do so would encourage the perception that the agency's actual movement toward long-term solutions is more conventional than real.

In the agency's "Forest Insect & Disease Leaflet 53," which James Hadfield distributed at the recent meeting on the DEIS, reference is made to a spruce budworm epidemic in the Rocky Mountains which has persisted since 1949 "in spite of repeated insecticidal treatment between 1952 and 1966 of more than 6,000,000 acres (2,430,000 ha) of forests." No doubt the land managers in that situation were confident that the strategy of "managing the current outbreak" would suffice. Clearly it did not, and the agency has since realized the need for long-term strategies. At the same time, agency officials admit that the research budget earmarked for spruce budworm research is inadequate to produce data needed to plan long-term solutions to the massive infestations of this insect pest. This leaves the public understandably skeptical of the agency's capability of planning and realizing integrated pest management for this or any other major forest pest.

We would like to see lobbying by the agency stepped up to acquire research funding not only for spruce budworm studies but studies of other insect pests likely to remain endemic in the region's ecosystem.

As for the alternatives arrayed in the DEIS, agency personnel have admitted privately that Alternatives A and C are politically impossible in Oregon, leaving only B and D as practicable. However, by endorsing both of them as "preferred," the agency is, in effect, endorsing neither. Is not the preferred alternative supposed to let the public know what the collective wisdom of the agency is? As with the recent vegetation management EIS, it would appear that the spruce budworm DEIS takes no position other than to reflect what regional politics will allow.

Equally troubling is an apparent internal contradiction in descriptions of Alternative D. In Chapter II -3, the implication is that carbaryl would be used as a supplement to the use of B.t.

with the proviso that "The choice of carbaryl or B.t. over the majority of the treatment area would be determined on a project-specific basis." However, in Chapter IV - 18, the document states, "It is assumed B.t. will be applied on sensitive areas, e.g., riparian/watershed, and carbaryl will be used on all other areas." Depending on the parameters used to define sensitive areas, this could mean a far greater application of carbaryl than the public might infer from reading the description in Chapter II. Certainly this needs clarification.

Of the so-called preferred alternatives, clearly the B.t.-only strategy is less harmfully environmentally. However, we feel that the DEIS overstates the harmlessness of wholesale applications of the biological insecticide. It is clear from research overlooked by your consultants that B.t. can dramatically supp ress populations of non-targeted Lepidopterans, for example.

If the Oregon Chapter were to endorse any of the four alternatives presented, it would be Alternative B on the grounds that it is the least ecologically destructive action alternative for immediate control of spruce budworm in the region. However, we feel that the DEIS reflects an ongoing tendency of public agencies to continue postponing the implementation of integrated pest management. For this reason, we close by reiterating our request for a supplemental EIS on agency planning for integrated pest management of the spruce budworm.

Sincerely,

Teresa Carp
Pesticides Coordinator
Oregon Chapter
Sierra Club

cc: Roger Ogden
Hon. Mark Hatfield
Hon. Les AuCoin
Hon. Bob Packwood
Hon. Peter DeFazio

LAUTERBACH FORESTRY SERVICES
P. G. LAUTERBACH, Consulting Forester
1140 N. CASCADE
TACOMA, WA 98406
(206) 752-1628

Dec 20, 1988

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Pacific Northwest Region
U.S.D.A. - Forest Service
P.O. Box 3623
Portland, Or 97208

Dear Sirs:

I am replying to the "Draft Environmental Impact Statement for Managing Western Spruce Budworm in Oregon and Washington".

After reviewing the Statement and Alternatives listed, I fully support Alternative "D" which would combine the use of B.t. and the insecticide Carbaryl. The use of B.t. near streams and other sensitive areas will help minimize rapid reinvasion of the insect from untreated islands of infestations and the use of the more effective insecticide Carbaryl elsewhere.

I also strongly urge an expanded research program to develop silvicultural and stand management strategies to reduce susceptibility of present stands to repeated spruce budworm infestations. When research has developed management strategies more resistant to budworm infestations, action programs should follow. The goal should be to maintain healthy forest less dependent upon insect control programs

Best wishes for a successful program in ~~1988~~ 1989

Sincerely

P. G. Lauterbach

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December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

DEC 22 1988
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Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone fulfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

2. The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These references should be corrected to read 1.0 lb. a.i./acre as Don Bilyeu has indicated it was intended to be. The use of 0.5 pounds would be contrary to the manufacturer's recommendations and the historical findings of spruce budworm control in the West.

3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and under-estimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

J. P. Hess
Signature

J. P. Hess
Name

51 Weems Way Selah, WA 98942
Address

000u52

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

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DEC 22 1988

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone filfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

2. The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These references should be corrected to read 1.0 lb. a.i./acre as Don Bilyeu has indicated it was intended to be. The use of 0.5 pounds would be contrary to the manufacturer's recommendations and the historical findings of spruce budworm control in the West.

3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

Greg McGuire
Signature

Greg McGuire
Name

710 S 45th, Yakima, WA. 98908
Address

Timber and Wood Products Group

Boise Cascade

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DEC 30 1988

Northeast Oregon Region
P. O. Box 610
La Grande, Oregon 97850
(503) 963-3141

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December 19, 1988

Mr. James F. Torrence
U.S. Forest Service
319 S.W. Pine
P.O. Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Please accept these comments as support for and supplemental to the response made by Mr. Gary Weiher of Boise Cascade, concerning the DEIS for managing Western Spruce Budworm.

I suggest that you select alternative "D" which allows for flexibility and site specific adaptability. Your field managers need to have the ability to use the best tools available to manage the current spruce budworm outbreak. This should include the use of the recommended application rate (1 pound/acre) of cabaryl.

Although the U.S. Forest Service does need to look at long term management techniques which will promote healthy and thrifty growing stands of commercial trees, this EIS is not that forum. The appropriate scope of this document is just as the decision needed states.

"......how to manage the current spruce budworm outbreak."

I am attaching my previous comments to the scoping process because many of the points raised there were addressed incompletely or not at all. Please review them and incorporate them into your final EIS.

An additional point that we discussed in Portland on 12/15/88 was the impact of secondary insects resulting from the low vigor of the trees which have been repeatedly defoliated by spruce budworm. As seen on the La Grande Ranger District, this can be a major factor in determining cost/benefits for suppression operations. This factor should be thoroughly discussed and displayed in the final EIS.

Please keep me informed as the final EIS is developed. I am very interested in the outcome.

Sincerely,

Robert C. Messinger
Region Timberlands Manager
Northeast Oregon Region

RCM/sp

Attachment: Letter of June 20, 1988

xc: Mark Boche
Jim Lawrence
Bob Richmond
Gary Rollins

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DEC 20 1988

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December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone fulfills the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

2. The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These references should be corrected to read 1.0 lb. a.i./acre as Don Bilyeu has indicated it was intended to be. The use of 0.5 pounds would be contrary to the manufacturer's recommendations and the historical findings of spruce budworm control in the West.

3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

Richard W. Wil...
Signature

Richard W. Williams
Name

4107 Englewood Ave Yakima, Wa 98908
Address

000057

December 16, 1988

RECEIVED

DEC 2 3 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

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Thank you for the opportunity to comment.

Sincerely,

M W Fisk
Signature

MARION W FISK
Name

640 FRANKLIN TIETON WA 98947
Address

December 16, 1988

000058

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

RECEIVED
DEC 20 1988

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

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Thank you for the opportunity to comment.

Sincerely,

Kevin M. Arneson
Signature

KEVIN M. ARNESON
Name

700 So. 69th Ave Yakima, WA 98908
Address

000059

Timber and Wood Products Group

Western Oregon Area
North Region
Post Office Box 290
Monmouth, Oregon 97361
503/838-1610

Boise Cascade

December 20, 1988

Mr. James Torrence
Regional Forester
U.S. Forest Service
319 S.W. Pine Street
Portland, Oregon 97208

Dear Mr. Torrence:

Thank you for the opportunity to comment on the U.S. Forest Service's EIS concerning treatment of the spruce budworm. We support Alternative "D" and urge you to adapt that option in your final decision. In our opinion, Alternative "D" provides the best opportunity to control the spruce budworm infestation and protect Oregon's valuable forest resources for a variety of uses.

Sincerely,

Bill Dryden

Bill Dryden
Chief Unit Forester

WAD:sb

cc: Russ McKinley
Bob Messinger
Allen Willis

NEIL GOLDSCHMIDT
GOVERNOR

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Executive Department

155 COTTAGE STREET NE, SALEM, OREGON 97310

RECEIVED

DEC 20 1988

December 20, 1988

James F. Torrence, Regional Forester
U. S. Forest Service
Pacific Northwest Region
P.O. Box 3623
Portland, OR 97208-3623

Subject: Management of Western Spruce Budworm
in Oregon and Washington
Draft Environmental Impact Statement
PNRS# OR881103-008-4

Thank you for submitting the subject Draft Environmental Impact Statement for State of Oregon review and comment.

Your DEIS was referred to the appropriate state agencies for review. No comments were received on this project, however the Department of Forestry advised that they would be submitting comments at a later date.

Sincerely,

INTERGOVERNMENTAL RELATIONS DIVISION

Dolores Streeter

Dolores Streeter
Clearinghouse Coordinator

1378T

EAST OREGON FOREST PROTECTIVE ASSOCIATION

PRINCIPAL PLACE OF BUSINESS - JOHN DAY, OREGON

PROTECTING FOREST and RANGE LANDS FROM WILDFIRE and OTHER DESTRUCTIVE FORCES

December 19, 1988

000061

James F. Torrence, Regional Forester
Pacific Northwest Region
319 S. W. Pine
P.O. Box 3623
Portland, Oregon 97208

RECEIVED

DEC 20 1988

Dear Mr. Torrence:

Re: DEIS - Western Spruce Budworm

The East Oregon Forest Protective Association represents private forest land owners in much of eastern Oregon. We are organized to enable our members to take collective actions regarding forest protection problems.

We urge your selection of alternative D as outlined in The Draft Environmental Impact Statement for Managing Western Spruce Budworm in Oregon and Washington. This alternative would combine the use of B.T. and the chemical insecticide, carbaryl, as the situation warrants. Effective control of this destructive insect is needed. We believe that alternative D provides greater flexibility and is well within any margins of safety required.

Since the USDA gives special emphasis to the development and use of efficient and environmentally acceptable integrated pest management systems, this preferred alternative can best serve that objective.

We appreciate your keeping us informed about the program.

Sincerely,

Ken Shrum

Ken Shrum, President

KS:vs
cc: Leroy Kline, Oregon Department of Forestry
East Oregon FPA Board of Directors

Member of Oregon Forest Protection Association
Office of Secretary-Treasurer - 1149 Court Street N.E., Salem, Oregon 97301
Telephone 371-2942

000062

COMMENTS on
Draft Environmental Impact Statement

Management of Western Spruce Budworm
in Oregon and Washington

To: James F. Torrence
Regional Forester
Pacific Northwest Region

From: Washington Environmental Council
Timber/Fish/Wildlife Section
4516 University Way N.E.
Seattle, WA 98105
December 16, 1988

Thank you for the opportunity to respond to the Draft EIS for "Managing Western Spruce Budworm In Oregon And Washington." We appreciate the enormous effort that goes into researching and writing an environmental impact statement.

Though the pros and cons of B.t. were adequately discussed, other important issues have been poorly presented. There are at least three oversights which need to be fully addressed in the Final EIS:

1. The Draft EIS falsely implies that carbaryl is an ideal pesticide to use against the spruce budworm, a pesticide with few negative environmental drawbacks. The DEIS fails in its discussion and its literature review to cite **numerous** studies which question carbaryl's effectiveness, safety record, registration history, carcinogenic properties, side effects, problems with drift, and environmental impacts.

2. After 30 years of mixed short-term results in battling spruce budworm with insecticides, the two DEIS response alternatives to spruce budworm management are not the answer to the problem, yet the Draft EIS pays almost no attention to long-term strategies and solutions.

3. The present and future trend for governmental agencies in dealing with the spruce budworm program is through Integrative Pest Management, which includes tools and techniques which were barely considered in the Draft EIS.

THE MANY PROBLEMS ASSOCIATED WITH CARBARYL

Carbaryl should not be recommended as a proposed alternative for direct suppression against the spruce budworm.

The DEIS states, "a certain amount of toxicity to a wide variety of insects and other arthropods may be expected." Many studies show that carbaryl can be more toxic to predators, parasitoids, and other beneficial organisms than to "pests" (Jepson 1975, Karpel 1973, Perssing 1982, and Sutton 1979). Applications of carbaryl to kill one insect species has resulted in outbreaks of other pests following their release from control by the predators that were killed (Dean 1976, DeBach 1965). Gunthart (1965) showed that the egg-laying capacity of pest mites is increased by carbaryl. As was mentioned in the DEIS, "Carbaryl is very toxic to honey bees." How carbaryl's impact on bees, especially wild populations, would be mitigated was not discussed.

The DEIS dealt with carbaryl's adverse effects on quail and pheasant. USDA (1979) research concluded that birds are affected by carbaryl through temporary habitat abandonment, a reduction in food supply, (Barr, 1979) decreased growth, and increased liver and kidney weight (Bursion 1977), and depressed brain cholinesterase activity (Zinkl 1977, Richmond 1979). Extensive pre- and post-spray bird censuses in conection with two carbaryl applications in New York revealed a "consistent gradual decline in bird numbers, species richness, and diversity during the eight weeks following spraying." The Washington Department of Wildlife regards the aerial spraying of carbaryl "to represent a risk to birds and small mammals, mainly through reduction of the insect food resource during the critical nesting period."

Due to carbaryl, "there may be a 50-100% reduction in aquatic insect populations in treated streams and ponds" (Burdick et. al 1960). Stratham (1978) found that a low level of carbaryl greatly increased the toxicity of 2,4-D, dieldrin, rotenone, and pentachlorophenol to trout. Vershevern (1983) reported carbaryl being toxic to various aquatic organisms in quantities as low as 0.1 part per million to algae, and six parts per billion to Dungeness crabs.

There is no mention in the DEIS of Keene's (1983) report of over 100,000 fish being killed in a single incident in Oregon when a tank truck carrying 2,000 gallons of carbaryl overturned in a creek.

The DEIS states that carbaryl "is not persistent." There was no mention of Neber's (1982) study which found carbaryl had not significantly degraded in trees during a 75 day period following spraying. The DEIS quotes Gibbs (1984) who reported residues were detectable in ponds 14 months after spraying for spruce budworm and some amphipod populations had not recovered after more than three years. Not persistent? Carbaryl has been reported in groundwater in at least two California counties (Ramlit and Associates, 1983). Sixteen months after spraying carbaryl to a Congaree sandy loam, six percent of the applied carbaryl was found in the upper one meter of soil. Carbaryl was detected at up to 60 ppb. in underlying ground water within two months and persisted through the eighth month (LaFleur, 1976). A Russian study of forest carbaryl application reported decreased in male and rodent populations without observable recovery in two years.

The DEIS states that carbaryl "does not accumulate." Hinkle (1982) reported carbaryl accumulating in aquatic biota -- accumulation ratio 1,064 ppm. in trout bile, 3.6 and 4.0 in lake trout, and coho salmon in aquarium of 2.6 ppm.

Human Health

The DEIS admits there are a number of data gaps and much uncertainty identified in the risk assessment of using carbaryl. However, some data indicates that carbaryl poses a risk to human health.

Abnormal sperm head morphology was reported in human workers with known exposure to carbaryl (Wyrobeck et al. 1981). In studies of rodents exposed to carbaryl, it was shown to reduce sperm counts, adversely affect sperm motility and increase sperm abnormalities (Degraeve et al 1976; Kitagawa et al 1976; Shtenberg & Rybakova 1968). None of these studies are mentioned in the DEIS.

"Mutagenic chemicals are recognized as posing a potential risk to human life because of their ability to cause heritable changes in genes and chromosomes. Such germline changes, for example, can lead to spontaneous abortions, birth defects, or the accumulation of deleterious mutations in the human gene pool. In addition, somatic mutations may be involved in the etiology of cancer" (EPA 1981). EPA's 1981 report quotes from a number of studies: "Positive responses have been reported in three gene mutation test systems (bacteria, Drosphila, and mammalian cells, in culture) using

carbaryl (McCann 1980; Cook et al 1977; Rshia 1978, Egert & Greim 1976, Brzheskii 1972, Ahmed et al 1977). In addition, the results of cytogenetic tests suggest that carbaryl may induce chromosomal aberrations in mammalian cells in culture (Ishidate & Odashima 1977, Kazarnovskava and Vasilos 1977). Carbaryl has been shown to cause unscheduled DNA synthesis, which is indicative of primary DNA damage in cultured human cells (Ahmed et al 1977). "Although there are inadequacies in the available studies, the results, when considered together, are strongly suggestive that carbaryl may act as a mutagen" (EPA 1981). The DEIS lists 21 EPA reports or studies in its cited literature, but not the 1981 document quoted above.

Teratogenicity is the ability to produce defects in the developing fetus. Teratogens induce birth defects during pregnancy. Although there has been a great deal of debate surrounding the teratogenicity studies for carbaryl, it has been shown to cause birth defects in dogs, rabbits, and guinea pigs. The dog studies conducted in the late 1960's are of particular concern because they indicate that birth defects were inducted at low doses of carbaryl (EPA 1980). The EPA Scientific Advisory Panel in 1980 recommended that product labels bear the warning: "Exposure to carbaryl during pregnancy should be avoided."

Carbaryl has been found to depress the immune resonse in rabbits (Street & Shurma 1975) and to increase the susceptibility of human cells to viral growth (Abrahamsen & Jerkofsky 1981). These studies were not cited in the DEIS. Concern over the viral enhancement effects of carbaryl led a panel of physicians formed by the Maine State Department of Agriculture to recommend that state allow no uninformed or unconsented human exposure.

At the National Institute of Hygienic Sciences in Tokyo, 134 compounds were tested of which 63 were negative, even at does at which cell growth was markedly inhibited. Nearly all compounds known to be mutagenic in bacteria were also positive in this test. One of the chemicals tested was carbaryl, which cause a 35% chromosomal aberration in 48 hours. At the University of Bologna in Italy, carbaryl was found to give a mutagenic response.

Carbaryl is only conditionally registered by the EPA. Chronic toxicity, birth defects, and metabolism studies in dogs must be submitted and reviewed before EPA can judge what restrictions will be necessary under full registration (Mott 1986).

The DEIS does not address the issue of carbaryl's inert ingredients. The contaminents, solvents, preservatives. and other ingredients present in

Sevin are a trade secret; their toxicity and effects are unknown, since essentially all long-term testing is done only on carbaryl, the active ingredient of Sevin (O'Brien 1986).

The DEIS is simply wrong when stating "petroleum distillates are listed by EPA as inert ingredients of no toxiological concern." Quoting EPA, "The Environmental Protection Agency is concerned about petroleum distillates which occur in about 80% of all pesticide formulations as inerts or actives and pose significant regulatory problems ... the polynuclear aromatic hydrocarbons of petroleum distillates have a high potential for carcinogenity and the alliphatic content may pose problems as well" (EPA 1984a, EPA 1984b, EPA 1984c). In light of the above quotation, the DEIS misleads the public when stating, "The majority of studies examining the carcinogenic potential (of carbaryl) have been negative."

DRIFT

The DEIS errs in not discussing the problems associated with drift when aerial spraying. According to Von Rumkir (1975), less than one percent of a pesticide application may actually reach the target pest. Pimentel and Levitan report in BIOSCIENCE that most sprayed pesticides do not reach target pests. Even under ideal aerial application conditions, only about 50% of the pesticide reaches the target area, a 1975 EPA report stated. Robinson and Elmer (1978) found that "extensive and recurring damage to central Washington crops from 2,4D prompted research that found long distance transport of the herbicide ranging rom 10 -50 miles. In 1983, USFS monitoring of Sevin showed 70% of the streams in the area were contaminated. This occured despite the fact that 100 foot buffers were left. In Boise Cascade's 1987 application to spray carbaryl on 60,000 acres, 75 foot buffers were proposed. Dick Miller (personal communication) reported that 100 foot buffers were useless against carbaryl drift, and would results in 50% of the spray going into water. He also stated that only 25 drops of carbaryl in one mile of stream can adversely affect aquatic organisms. In light of the above research, the DEIS is not reassuring when stating, "A buffer zone will be left adjacent to streams, lakes, wetlands, and other waterways when applying carbaryl. This buffer strip must be at least one swath wide."

B.t. has not been mentioned in my comments, but due to the Forest Service's contention that the 1988 Oregon spruce budworm project was an outstanding success, that B.t.'s spraying costs are equivalent to carbaryl's, coupled with the extensive environmental and human health studies

documenting carbaryl as a dangerous substance, it seems abundantly clear that Region 6 should not be using carbaryl under any circumstances. Alternative D should be eliminated from consideration.

ALTERNATIVES TO CARBARYL

The DEIS treatment of alternatives to aerial spraying of carbaryl and B.t., both long-term and short-term are almost non-existent, despite the fact that 30 years of chemical treatment has not solved the budworm problem and may have even exasperated the situation. Managing for spruce budworm, district and forest level supervisors will need a variety of tools to consider such as siLvicultural techniques, fire management, and the introduction of predators and parasites. The DEIS only allows for one option: to aerial spray.

The DEIS recognized that "long-term management of timber stands through silvicultural treatments as a means to end the epidemic is an issue." Silviculture strategies for combating the budworm are a key issue which should have driven its own alternative in the DEIS. Regardless, whether the DEIS centers only on the "current spruce budworm outbreak," its recommendations and information will apply to insect outbreaks of all kinds in Region 6 and will set the course on how to react to future infestations.

In arguing against the $15 million spruce budworm spray project in Oregon, Waring and Gomack (1988) stated that decades of wildfire suppression in forests dominated by pine trees allowed an unnatural expansion of firs. An aggressive effort to restore the pine dominance offers the best long-term solution to the pest problem. Elimination of effective fire suppression has eliminated natural and frequent fires guaranteeing a gradual plant succession toward a more climax composition and shade tolerant (budworm susceptible) host species. Work done on the Bear Springs Ranger District by Mosser shows that underburning of fir can help alleviate the budworm problem.

Scholwater (1988) found that old-growth forests of the Cascades supported far more predatory invertebrates -- primarily spiders -- than plantations, 160 g/ha vs. 60 g/ha. This raises the question (not raised in the DEIS) of which pests within plantations could originate in old growth. Spiders are the primary invertebrate predator of the eastern spruce budworm (Morris 1967). Carlson et al (1984) determined that predation by ants and birds reduced spruce budworm damage to Douglas fir by 50%. Wiens (1975) showed that 50% of the food consumed bu northwestern birds is animal prey,

most of which is foliage-feeding insects. Takekawa and Garton (1984) estimate it would cost $1800 per square km. per year in insecticides to kill the same number of spruce budworm that were eaten by birds in forests of Northcentral Washington. Though the DEIS states that predators are ineffective in reducing budworm numbers during an infestation, predators' roles in checking spruce budworm populations during non-infestations need to be considered.

The DEIS did not quote Liebhold (1983) who believes that direct control of the budworm population will not even function as a temporary solution. Instead, "suppression of budworm populations will intensify the problem in that by reducing population levels, the treatment favors the dominance of budworm-susceptible stands and in the long-run, probably serves to intensify subsequent outbreaks."

INTEGRATED PEST MANAGEMENT

As the USFS in other regions and other state agencies begin moving toward Integrated Pest Management (IPM), Region 6 has taken a step backward in its DEIS by considering only the aerial spraying option. "IPM emphasizes natural controls of pest populations. This approach provides more effective and economical control" (EPA). A December 1977 memo states, "The policy of the USDA is to develop, practice and encourage the use of IPM." USFS 1982 FMA regulations state, "A basic principle in the choice of strategy is that it be ecologically compatible or acceptable."

The USFS Southwest Region (region three) is pulling away from carbaryl use due to its ineffectiveness. Rogers and Bennett (1984) report three years of carbaryl spraying on the Carson National Forest resulted in only short-term effectiveness.

Region 4 of the USFS has a policy of not using insecticides.

Region 1 of the USFS decided on a "no spray" policy because:

1. The high-cost of spray programs result in little or no forseeable benefits especially compared to the return on the investment on protecting the resource.

2. Insecticides are temporary solutions and would not prevent cycling buildups.

3. There are a lack of demonstrable resource losses and potential risks to the environment by spraying.

Respectfully submitted,

William J. Weiler
Washington Environmental Council
T/F/W Southeast Representative

United States
Department of
Agriculture

Soil
Conservation
Service

W. 920 Riverside, Rm. 360
Spokane, Washington 99201-1080

December 13, 1988

000063

James F. Torrence, Regional Forester
USDA-FS; PNW Region
319 S.W. Pine Street
P.O. Box 3623
Portland, Oregon 97208-3623

Dear Mr. Torrence:

We have reviewed your Draft Environmental Impact Statement Summary on the Management of Western Spruce Budworm in Oregon and Washington. It would appear the concerns of the Soil Conservation Service have been addressed, and we have no comments to offer at this time.

Thank you for the opportunity to review your draft summary.

Sincerely,

Lynda E. Brown (acting)

LYNN A. BROWN
State Conservationist

cc: G. Tibke, SRC, SCS, Spokane SO

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STATE & PRIVATE
FORESTRY

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DEC 2 1988

The Soil Conservation Service
is an agency of the
United States Department of Agriculture

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U.S. Government Printing Office: 1983-420-9 /1578

United States Department of the Interior

TAKE PRIDE IN AMERICA

OFFICE OF ENVIRONMENTAL PROJECT REVIEW
500 N.E. MULTNOMAH STREET, SUITE 1692
PORTLAND, OREGON 97232

December 14, 1988

ER88/931

000064

James F. Torrence, Regional Forester
Pacific Northwest Region
USDA Forest Service
P.O. Box 3623
Portland, Oregon 97 208

Dear Mr. Torrence:

The Department of Interior (Department) has reviewed the Draft Environmental Impact Statement for Management of Western Spruce Budworm in Oregon and Washington. The following comments are provided for your use and consideration when preparing the final document.

The U.S. Fish and Wildlife Service (Service) believes that the selection of the preferred Alternative B which provides for direct control utilizing only the biological insecticide B.t., would have the least impact to fish and wildlife resources. Conversely, Alternatives C and D which both utilize the chemical insecticide carbaryl, would likely have adverse effects to non-target fish and wildlife resources. Furthermore, the Service understands that B.t. and carbaryl have similar efficacy for controlling the target insect pest. Accordingly, the Service supports the selection of Alternative B as the preferred alternative for controlling western spruce budworm.

On October 20,1988, the Service provided the Regional Forester`s Office with a list of threatened and endangered species which may be present in the area of proposed western spruce budworm control in Oregon. The letter advised that if the USDA Forest Service determines (through its project specific analysis) that a listed species is affected by the proposed project, consultation under Section 7 of the Endangered Species Act should be initiated with the Service.

We appreciated the opportunity to comment.

Sincerely,

Charles S. Polityka

Charles S. Polityka
Regional Environmental Officer

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DEC 20 1988

20 December 1988

000066

James F. Torrence
Regional Forester
Pacific Northwest Region
319 SW Pine, P. O. Box 3623
Portland, OR 97208

RECEIVED

DEC 23 1988

Dear Mr. Torrance:

We wish to comment upon the DEIS for Managing Western Spruce Budworm in Oregon and Washington. We are laypersons without technical training in the fields related to this DEIS, but we have extensive personal experience and an abiding concern with the treatment of sensitive populations in pesticide programs.

Our family contains several individuals with hypersensitivity to various chemicals, particularly to many pesticides. We are quite aware of the fact that the medical community is divided about the definition of this condition; some would call our reactions allergic, while others would reject that term because these reactions are not always IgE mediated.

However, the fact remains that we have had too many frightening experiences from pesticied exposures, many of these exposures quite minimal ones, for us to contmplate any more with equanimity. Our children have experienced reactions ranging from headaches, mental disorientation and nausea, to extreme incontinence and seizures. In some of these cases, we have been able to identify the chemical to which we have been exposed; on other occasiòns, we were only able to ascertain that an exposure had occurred. We do know enough to be very concerned about exposures to most insecticides, including carbaryl, and also to have concern about the effect of supposedly "inert" ingredients, stickers and spreaders, like kerosene and diesel oil, both of which cause serious reactions in our children.

We therefore appreciate the fact that the DEIS recognizes that the factor of 100, used here to address the problem of sensitive populations, is not sufficient to prevent problems in all individuals. We strongly object, however, to the suggestion in chapter IV, 38 (and repeated in Appendix F) that the effects are likely to be contact dermatitis only, serious as that could be. In our case, exposures of the type contemplated in the DEIS would in all likelihood induce far more serious reactions, including very possibly seizures and immunosuppression. This DEIS suggests that it covers all likely problems, except for statistically rare individuals who would get rashes; in that area it is seriously inaccurate and inadequate.

Likewise, the DEIS suggests that allergic reactions are limited to responses to high molecular weight organic molecules or whole cells. Here again, the problem may be one of the terminoligical dispute over allergy, but we have never encountered such a distinction in the medical literature dealing with our condition, nor does that distinction seem to have any significance

in our experience. Our family responds to substances with widely varying molecular weights.

We hope that you will make a serious effort to address the problems which spray programs pose to individuals like us in your revisions of this DEIS. There are, for the record, significant numbers of us. We know of dozens of individuals in Salem alone who share our condition; there are certainly hundreds of us in the state of Oregon.

That community of chemically sensitive persons would be far better served by a pest control program that more seriously engaged the sources of pest problems, instead of attempting so single-mindedly to eradicate or control pests whose continued troublesome presence is taken as an unexamined given. But if pesticides are to be used, we ask that a more serious and realistic assessment be made of the risk to sensitive populations than is provided in this DEIS.

Sincerely,

Janet Nolley

Janet G. Nolley, M. S. W.

Kenneth S. Nolley

Kenneth S. Nolley, Ph. D.

December 16, 1988

000067

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone filfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

2. The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These references should be corrected to read 1.0 lb. a.i./acre as Don Bilyeu has indicated it was intended to be. The use of 0.5 pounds would be contrary to the manufacturer's recommendations and the historical findings of spruce budworm control in the West.

3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

Jerry Strayan
Signature

Jerry Strayan
Name

December 16, 1988

000068

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

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3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

Steven D West

Signature

STEVEN D. WEST

Name

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000069

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone filfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

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Thank you for the opportunity to comment.

Sincerely,

Joel Tompkins
Signature

Joel L. Tompkins
Name

December 16, 1988

Mr. James F. Torrance
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000070

Dear Mr. Torrance:

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Thank you for the opportunity to comment.

Sincerely,

Jeffrey L. Wetherly
Signature

12-21-88
Name

December 16, 1988

000071

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

Michael G McGreevy
Signature

MICHAEL G. McGreevy
Name

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000072

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Thank you for the opportunity to comment.

Sincerely,

Lyle K. Eddings
Signature

LYLE K. EDDINGS
Name

December 16, 1988

000073

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

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Sincerely,

Steven R Tveit
Signature
STEVEN R TVEIT
Name

December 16, 1988

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Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000074

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Thank you for the opportunity to comment.

Sincerely,

David K Whitwill
Signature

DAVID K. WHITWILL
Name
330 E 9TH KETTLE FALLS, WA
99141

December 16, 1988

Mr. James F. Torrance
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000075

Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

Richard D Just
Signature

Richard D. Just
Name

Rt 1 Box 19-A Colville, WA 99114
Address

December 16, 1988

000076

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

James W Harberd
Signature

James W HARBERd
Name

P.O.Box 552 Kettle Falls Wa. 99141
Address

WASHINGTON STATE DEPARTMENT OF
Natural Resources

BRIAN BOYLE
Commissioner of Public Lands

OLYMPIA, WA 98504

December 21, 1988

RECEIVED

DEC 30 1988

000077

MEMORANDUM

TO: James F. Torrence, Regional Forester
USDA Forest Service

FROM: Art Stearns, Supervisor *Arden Olson for*
Department of Natural Resources

SUBJECT: Revision to EIS Comments of 12-20-88

The attached copy of DNR's comments on the draft EIS "Management of Western Spruce Budworm in Oregon and Washington" contains additional information on our preferred alternative.

Please disregard the earlier version that was dated and mailed to you on 12-20-88. Thank you.

AS:aof

cc: Laura Eckert, DNR
Arden Olson, DNR
Harry Anderson, DNR
Bob Dick, WFPA
Marcy Golde, WEC
Bill Ciesla, USFS Region VI
Roger Ogden, USFS Region VI
Bill Howard, Boise Cascade
Len Rolph, Champion International

WASHINGTON STATE DEPARTMENT OF
Natural Resources

BRIAN BOYLE
Commissioner of Public Lands

OLYMPIA, WA 98504

December 20, 1988

RECEIVED
DEC 27 1988

James F. Torrence
Regional Forester
USDA Forest Service
P.O. Box 3623
Portland, OR 97208

Dear Jim:

We have received the draft EIS "Management of Western Spruce Budworm in Oregon and Washington". In general, we find that the document adequately addresses the issues and its scope is sufficiently broad. The attached comments are offered as suggestions for revision in the final document.

We appreciate the opportunity to review your draft EIS and hope you find our comments constructive.

Sincerely,

Laura Eckert, Deputy, for
Art Stearns
Supervisor

AS:ag

cc: Laura Eckert, DNR
Arden Olson, DNR
Harry Anderson, DNR
Bob Dick, WFPA
Marcy Golde, WEC
Bill Ciesla, USFS Region VI
Roger Ogden, USFS Region VI
Bill Howard, Boise Cascade
Len Rolph, Champion Int.

12-21-88

Comments on the Draft EIS
"Management of Western Spruce Budworm in Oregon and Washington"
from the Department of Natural Resources

Several referenced publications cannot be found in APPENDIX R, Bibliography, Literature Cited.

Summary, page 1. Introduction, paragraph 5 versus Decision Needed, paragraph 1.

Is it the intent of this document to develop and set forth strategies for long-term management, or will that continue to be left up to the Forest planning process? Some clarification may be necessary here. (See APPENDIX D, Prevention, par. 2.)

Summary, page 3, "Effectiveness of Treatment Methods..."

Bacillus thuringiensis is the only treatment method discussed. All proposed methods should be mentioned.

Summary, page 4, Planning Questions

Question 2. Question pertains to effectiveness. Response is incomplete. Information regarding impact is superfluous and could be deleted.

Question 4. Incorrect response--Question relates to scenic values and recreation value but response addresses damage to wood fibre production.

Summary, page 5, USDA Forest Service Management Objectives, B. Oregon and Washington State Forest Practices Act.

Mentions only Oregon, what about Washington?

Summary, page 6, Development of Alternatives, Alternatives Considered But Eliminated From Detailed Study.

First paragraph indicates that the alternatives eliminated and the rationale for their elimination will be discussed. However, the rationale for elimination of alternatives is missing from the discussion.

Summary, page 7. Comparison Of Alternatives. Planning Question #2, How effective are the treatment methods?

This section should point out that carbaryl is more effective in controlling extremely high populations of western spruce budworm than Bacillus thuringiensis and produces more consistent results due to a larger application window. When this is taken into consideration, the likelihood of resurgence is probably more equal between the two pesticides. Resurgence is also a potential problem with B.t., albeit for a different reason. Operational use of B.t. and carbaryl in 1988 showed that B.t. continues to present a greater problem regarding the variability of treatment.

Alt. C. The probability of the western spruce budworm developing a tolerance to carbaryl is extremely low due to the long time internals between treatments on forest lands.

Summary, page 9. Planning Question #7, What is the timeliness of treatment for this and future outbreak cycles.

This section is confusing. We do not believe that history of use of carbaryl in the Pacific Northwest Region supports the statement regarding sublethal dosages and population behavior.

Chapter I, Purpose and Need for Action, page 8, Planning Questions.

Question #2, How effective are available treatment methods in reducing the insect population? Is one method of control substantially more effective? Further clarification of the technical base of knowledge on these questions needs to be addressed.

Chapter IV, page 9, Environmental Consequences, Background, Regional Environmental Effects, par. 1.

The western spruce budworm outbreak has not spread across the Cascades into west-side forests in Washington.

Chapter IV, page 7, Seed Production Potential, Alternatives B, C, and D.

Amend par. #1 "Application of B.t." to include carbaryl.

Chapter IV, page 10, Efficacy, Alternative B.

This is the appropriate place to discuss the inadequacy of B.t. in controlling western spruce budworm outbreaks that consist of extremely high larval populations.

Chapter IV, page 15, Carbaryl, Mammalian Toxicity, par. #2.

Proposed rate for future suppression programs should be 1.0 lb a.i./acre of carbaryl, not "0.5 lb a.i./acre." Also see Avian Toxicity, par. #4, and Chapter IV, page #22, Fate in Plants, par. #2, bottom of page.

You need to find out if your consultant on APPENDIX F, Human Health and Environmental Risk Assessment, etc, used on application rate of 1 lb a.i./acre for carbaryl. If not, then their assessments will be inadequate for future operational use of carbaryl at 1 lb a.i./acre.

Preferred Alternative:

The Department of Natural Resources prefers "Alternative D" proposing the use of both B.t. and/or carbaryl as the situation warrants. This alternative offers the forest manager the greatest flexibility for reducing impacts caused by the western spruce budworm.

RFD Box 55
Deadwood, Oregon 97430
21 December 1988

RECEIVED

DEC 2? 1988

Roger M. Ogden
Western Spruce Budworm Project Leader
USDA Forest Service
Pacific Northwest Region
P. O. Box 3623
Portland, Oregon 97208

000078

Dear Mr. Ogden:

Enclosed is my response to your request for public comment on the Draft Environmental Impact Statement for Managing Western Spruce Budworm in Oregon and Washington.

The activities and management of the National Forests is of great interest and concern to me, both because our farm (Cedarglen) is surrounded by the Siuslaw Forest and because of a deep and long-standing respect and affection for the public forests of our nation.

I would like especially to express my sincere appreciation to you and other Forest Service people who have been so generous, with their time and professional wisdom to aid my understanding of the Budworm Project and its relation to overall forest management.

Sincerely,

Don Carlton

Don Carlton
503-964-5571

RESPONSE TO: MANAGING WESTERN SPRUCE BUDWORM IN OREGON AND WASHINGTON
Draft Environmental Impact Statement
Region 6 21 December 1988

COMMENT: The Forest Service is encouraged to formulate and implement an aggressive and adequately funded research program to achieve operational capability for long-term integrated forest pest management, with emphasis on preventive measures.

DISCUSSION: The DEIS recognizes that the current budworm outbreak is part of a larger complex of forest pests and is caused, in part, by past management practices. Clearly there is a need for more complete understanding of complex forest processes. There is heavy responsibility on forest managers who advocate intensive practices to avoid the adverse effects which often accompany man's intervention in biologic systems. The predominant goal should be a healthy forest with appropriate long term productivity under low stress conditions. Research planning should be comprehensive and broad based. Consideration should be given to opportunities for enhancing other forest resources as alternatives to or along with timber.

COMMENT: The limited scope of the DEIS foreclosed the development of a full range of appropriate actions.

COMMENT: The Final EIS should include both short and long term strategies.

DISCUSSION: The NEPA process places great emphasis on full consideration of the cumulative effects of proposed actions. Limiting the scope of this EIS to management of the current outbreak by short term means has the adverse effect of precluding consideration of a full range of options for managing the budworm and in a larger sense management of forests susceptible to periodic outbreaks. For example, it may well be that significant areas of these forests should not be managed intensively for timber if the cumulative effects of site quality, climate, management options and costs and high susceptibility to a broad range of forest pests are completely evaluated.

The history of pest control programs which focus on short-term strategies indicates that they frequently take on a life of their own and are operationally continued beyond their need or when better solutions could be available.

The DEIS's attempt to address the long-term issue is inadequate, specifically because the commitment (I-3) lacks substance and concrete planning. For example, it is unknown if the necessary research can be conclusively completed within the 5 years. Past and current levels of research funding are grossly inadequate to support even known research needs and prospects for significant increases are dim unless decisive management action is taken.

The Final EIS could remedy this deficiency in part by:

- providing specific links and guidance to individual Forest Plans which address both short and long term measures -- and the next planning cycle is too long to wait.

- including among its planned actions a credible and operationally sound set of funded research activities which will contribute to environmentally sound long-term solutions.

COMMENT: The extent of the treatment program to control the current budworm outbreak should be significantly reduced.

COMMENT: The objectives of the active control program should be clearly and restrictively defined.

DISCUSSION: This DEIS addresses the questions: Is an active program needed to control the current budworm outbreak? and if yes, what method should be used? (I-3) It should also address the question: If yes, what are the specific objectives of that control program?

From the very limited information provided in the DEIS my conclusion is that it is doubtful that a major control program is warranted for the current outbreak.

> The average stand volume loss in north-central Washington after a 10 year outbreak was 2.9% of predicted growth (IV-5).
>
> "In Idaho, stand volume losses were calculated as 1 percent less than predicted growth." (IV-5)
>
> [For the No-Action Alternative the] "maximum total defoliation should be no greater than 25 percent with less than 3 percent of this in mortality." (IV-3)
>
> "In an extreme case, tree mortality amounted to 39 percent of the total number of trees per hectare ... with smaller, suppressed trees sustaining higher mortality." (IV-6)
>
> "Preliminary fiber impact estimates indicate their magnitude will not be sufficient to influence forest management activity schedules." (E-3)

The DEIS did identify economics as a major issue.

> "The benefits and costs of alternatives being considered for dealing with the budworm outbreak should be displayed and compared." (I-7)

And it did claim a reasonably foreseeable adverse economic impact.

> "Predicted decline in forest growth as a result of budworm defoliation can be reasonably estimated. In the area of social and economic effects there is sufficient information to provide a clear basis for making a choice among options with confidence." (IV-42)

The DEIS however failed to display and compare the benefits and costs in a meaningful way and failed to provide an estimate of the predicted decline in forest growth resulting from the current budworm outbreak.

The DEIS did assert that the "cumulative effects [of the No-Action alternative] on timber would be a continuing and expanding loss of fiber production..." and that the "... forests would exhibit a maximum amount of mortality caused by an outbreak allowed to continue...". (IV-6) But without quantitative data these statements have little value.

The NEPA process asks the decision maker and the public to weigh carefully the anticipated net benefits of the planned action against reasonably foreseeable adverse consequences. Some measure of overall economic benefits and costs is essential in order to make a responsible and informed response to this DEIS.

By focusing on the methodology of economic analysis of individual candidate treatment areas the DEIS failed to include available information needed to provide a clear basis for making a choice between the no-action and action alternatives. The structure and content of the DEIS strongly implied that the selection of an action alternative was a foregone conclusion and that the real decision centered on which method to use.

The DEIS should also have included sufficient information to provide a clear basis for choice among the action alternatives specifically concerning overall economic factors of the sort which would influence experienced managers, e.g. treatment costs, operational flexibility, risks of ineffective treatment.

Despite the lack of objective evidence provided by the DEIS my respect for the professional wisdom of the Forest Service leads me to believe that there is some level of threat to the health of the forest. Some individual analysis units may be at risk of significant stand damage. Some private forest managers may wish to pursue an aggressive control program. The outbreak may resurge. For these reasons it is appropriate for Region 6 to have in place a well planned and environmentally sound program.

This program should have clearly defined objectives. To illustrate, there are some obvious non-objectives: to kill every budworm, to prevent all growth loss, to preserve every viewshed, to spend all available funds. As the DEIS points out, objectives will differ among forest land ownerships. The following suggestions pertain primarily to National Forest lands.

COMMENT: The primary goal of the budworm control program should be to assure the basic health and long-term multiple resource productivity of the forest.

DISCUSSION: My particular areas of concern relate to the preservation of soil productivity, stream structure, fish habitat, watershed quality, riparian area quality and the prevention of soil erosion. From my limited understanding of forest processes it would seem that this would indicate that emphasis be placed on potential tree mortality as an indicator of needed action, particularly when a significant reduction of vegetative cover is involved.

Of minimal concern to me is the preservation of viewshed quality, except perhaps in well developed recreational areas. The public should be exposed to the normal processes of a working forest. This would seem to indicate that less emphasis be placed on controlling extensive defoliation where there is little risk to the stand.

COMMENT: A secondary goal should be to prevent or reduce the loss of economic value of forests and the future supply of timber where a truly valuable asset is at serious risk. Growth loss alone should not be a sufficient reason to justify an active control program.

DISCUSSION: The DEIS correctly states that "...the public want[s] to know if their money is being spent wisely." (I-7)

Regional guidelines should be formulated to provide clear and specific criteria which must be met to justify a particular treatment project. These should be included in the Final EIS along with an explanation of their economic and environmental consequences. They should include threshold values of PNV gain and for Benefit/Cost ratio.

There are many competitors for expenditure of federal funds. Many worthy causes remain underfunded. Many people are concerned about the national budget deficit. I am troubled by the emphasis in the DEIS on a B/C ratio "greater than 1.0". The 1988 Budworm EA indicates that the most likely B/C ratios for units considered for treatment range from 3 downward (C-12). Many private companies require rigorous justification for the expenditure of investment funds and a threshold B/C ratio considerably higher. Although I understand the limitations of the government funding process it is discouraging to learn that right within Region 6 the research activities which will eventually lead to long-term solutions for the budworm and other forest pests is tragically underfunded. The annual treatment program probably spills (bad choice of words) enough to amply fund the needed research.

COMMENT: To the extent that any active budworm control is thought to be needed I urge that B.t. be selected as the only insecticide authorized by the Decision Notice.

DISCUSSION: Review of the Comparison of Alternatives (II-4ff) shows that in the four planning questions where the three action alternatives differed (#2, 3, 7, 8) Alternative B clearly is predicted to have the most desirable effects with least environmental risk. In fact it is difficult to find reasons to defend either alternatives C or D based on the information contained in the DEIS.

Although B.t. is not without environmental and human health risks, carbaryl presents risks which clearly outweigh any benefits to be gained from a treatment program.

There are two areas of forest environmental concern, aquatic and terrestrial. More information is available about the aquatic systems. Carbaryl is harmful to many important aquatic invertebrates even in very small concentrations. While not usually lethal, it causes added stress in young fish. Spray drift from aerial application is very difficult to control. It is nearly impossible to keep out of water courses on sloping ground. As a practical matter treatment with carbaryl will inevitably lead to its entering the aquatic system to a greater or lesser extent. Precautions and monitoring increase treatment costs and reduce efficacy.

Less information is available concerning the widespread application of carbaryl to the much more complex forest terrestrial systems. Research data from small test plots have limited value, extrapolation to predict the effects of a broad spectrum insecticide treatment over thousands of acres must be viewed with caution. While they could validly confirm a positive finding of significant adverse effect they are insufficient to conclude a negative finding of no serious environmental damage.

It cannot be assumed that the complex biologic systems of the forest will completely recover from even a single treatment with a broad spectrum insecticide. Invertebrate population dynamics may be affected over an extended period of time. Of particular concern is the effect on the complex web of forest decomposers. Many arthropods, known and unknown, play vital roles in decomposition, a process essential to the health of the forest.

Applicable research data is very limited and the conclusions in the DEIS are little more than speculation. While important information is lacking it is fair to conclude that the adverse biologic effects would be less from treatment with the narrower spectrum B.t. than with the much broader spectrum insecticide carbaryl.

Experience has shown that there is a small but definite probability of accidental spills occurring during treatment operations. The adverse environmental effects of spills and other unintended events, e. g. spraying sensitive areas, are much less with B.t. than with carbaryl.

It is my understanding that the Forest Service has made significant advances in the technology of B.t. formulation and application to the point where treatment programs, carefully planned and implemented, have a high probability of achieving target population reductions. This should eliminate most of the legitimate reasons for including carbaryl as a treatment option.

* *

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

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GA 30341

Centers for Disease Control
Atlanta GA 30333
December 21, 1988

Roger M. Ogden
Western Spruce Budworm
Project Leader
USDA Forest Service
Pacific Northwest Region
319 SW Pine, P.O. Box 3623
Portland, Oregon 97298

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Dear Mr. Ogden:

We have reviewed the Draft Environmental Impact Statement (DEIS) for "Management of Western Spruce Budworm in Oregon and Washington" and we are responding on behalf of the U.S. Public Health Service (USPHS). In addition to a review in our office at CDC, our comments reflect reviews by two other USPHS agencies: the National Institute for Occupational Safety and Health (NIOSH) and the Food and Drug Administration (FDA). As an overall comment, we were pleased to find a thorough assessment of the impacts of pest management methods on human health and safety in this DEIS.

The concerns of USPHS reviewers centered on the pesticides proposed for use in this project. The NIOSH reviewer, who has had recent experience in surveying occupational health and safety hazards of biological insecticides in Oregon, recommends the use of Bacillus Thuringiensis (Bt) over chemical insecticides. In the NIOSH study of Bt application in Lane County Oregon (report attached), the biological insecticide was found to be a safe and effective means for managing insect infestations. In that study, however, it was recommended that agencies considering large scale Bt application pay specific consideration to those situations where a small percentage of individuals (residents or workers) may experience adverse health effects because of individual susceptibility to biological insecticides. In the forthcoming project, therefore, it is strongly recommended that the Forest Service implement a surveillance program which would identify and follow immuno-suppressed or hypersensitive individuals in the application area who may be at risk. Every effort should be made to fully advise the general public as to the time and area where Bt is to be applied.

The public health risk due to the possible use of carbaryl in this project was well documented in the DEIS. While this chemical is relatively safe, cautionary measures are especially justified to minimize the potential for

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occupational exposures. Measures should include recommendations for appropriate personal protective equipment and a carefully designed program of work practices to minimize exposures during application. As with Bt application, the general public should be fully advised as to the time and area where carbaryl is to be applied.

At actual field sites, it is not reasonable to expect application workers to make a consistently correct selection and use of protective equipment under physically stressful field conditions. The Final Environmental Impact Statement (FEIS) should include more details of proposed management/supervisory practices which are planned to insure compliance with the proper selection and use of personal protective equipment in the field.

To indoctrinate and reinforce worker understanding of Forest Service exposure control policies, training and reorientation on approved work practices should be offered at the beginning of the pesticide application period and at frequent intervals throughout the application period (including inspections of personal protective equipment for proper use, wear, contamination, etc.). Demonstration and training should be conducted at actual work sites to reflect representative working conditions. Supervisors should strictly enforce the proper wear and care of personal protective equipment at all times.

Residues from Bt or carbaryl on crops could be a concern. If substantial overspray or spray drift into crop areas could occur during pesticide application, the Forest Service should develop techniques to investigate if any substantial settling on crops has occurred in order to reduce and/or eliminate residues which might enter the human food chain.

Thank you for the opportunity to review this DEIS. We hope that our suggestions are useful in the practical translation of the theoretical assessment of exposure risks to the minimization of risks during actual insecticide applications. Please insure that we are on your mailing list for the FEIS for this project as well as other documents which are developed under the National Environmental Policy Act (NEPA).

Sincerely yours,

David E. Clapp

David E. Clapp, Ph.D., P.E., CIH
Environmental Health Scientist
Special Programs Group
Center for Environmental Health
and Injury Control

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MEMBRANES, INC.

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December 19, 1988

Mr. James F. Torrence
Regional Forester
Pacific Northwest Region
USDA Forest Service
P.O. Box 3623
Portland, OR 97208

Re: Draft Environmental Impact Statement for Managing Western Spruce Budworm

Dear Mr. Torrence,

I note with some concern the comments in the Draft Environmental Impact Statement for Managing Western Spruce Budworm regarding the use of insect pheromones to control western spruce budworm. Of particular concern is the statement on page II-1: " ...to date, this technique has not been successful against western spruce budworm. Thus, this technique is not a realistic control option...".

I can not agree with this statement. Use of pheromones against western spruce budworm has only been tested at a research level. Brooks et al. (1987), in the CANUSA Spruce Budworms Program publication Western Spruce Budworm states that: "...investigators have concluded that the technique has shown enough promise to warrant continued research.". Pilot or pre-operational testing has not been conducted on this technology, but the potential for a non-toxic, efficacious and cost-efficient method does exist. There have been substantial improvements in semiochemical technology, as a whole, since the USFS was last able to evaluate its use for western spruce budworm.

For example, a pheromone formulation for pink bollworm (a pest of cotton) which can be sprayed from conventional aircraft equipment has just received EPA registration by Consep Membranes, Inc. This formulation provides over 20 days of control of the pest with one application, at costs which are very competitive with pesticides. The pheromone has an LD50 of ¶34,600, an exemption from tolerance in or on cottonseed (a food crop), and no restrictions on days to harvest or on entry by field workers. The material is water-insoluble, and evaporates or degrades very rapidly to

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innocuous metabolites. Consep has also completed field testing on a season-long formulation for control of oriental fruit moth (a pest in peaches) which provides 3 months of control by mating disruption from a single ground application. The pheromone is again exempt from tolerance on peaches, and there are no days to harvest or entry restrictions. The LD50 is ¶20,000 mg/kg, and there was no mutagenic potential shown in an Ames Assay on the pheromone mixture.

The pheromones for western spruce budworm are essentially similar in chemical structure to those compounds which have been evaluated for the EPA as part of their toxicology investigations. The EPA recognizes the reduced risk and impact of pheromones, and has provided for exemption from certain tests, provided the compounds have acceptable performance in Tier 1 testing. None of the pheromone compounds showed measurable acute oral toxicity (i.e. no test animals died at any of the dosages tested, for any of the compounds). EPA has always granted exemptions and waivers for pheromones.

Investigations into the use of mating disruption for eastern spruce budworm have continued, even though researchers on the west coast have been unable to complete their preliminary studies. These studies have examined pheromone formulations which are easily sprayed from air-craft, and which provide the long-term duration needed for control of the pest.

I therefore believe it is unconscionable for the Western Spruce Budworm Project to discount the potential of the use of insect pheromones as part of the control program. The pheromones are species-specific, and will not affect any other organisms, even other lepidoptera. I should hope you could support the PNW researchers to accelerate the investigation of this technique, or would see fit to include development of this technology as part of your programs.

Yours sincerely,

Michael Banfield

Michael G. Banfield
Product Development Manager

MGB/sv

cc. Dr. R.G. Mitchell
Dr. G.E. Daterman
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December 21, 1988

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Regional Forester

Mr. James F. Torrence
U.S. Forest Service
319 S.W. Pine
P.O. Box. 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Boise Cascade Corporation is a major timberland owner and wood products manufacturer, directly employing over 3500 people in the Northwest and managing over 950,000 acres of timberland that is susceptable to western spruce budworm damage. The control of budworm populations and their damage is of paramount importance to the people of Boise Cascade. With this in mind, please consider these comments to the Draft Environmental Impact Statement for the Management of Western Spruce Budworm in Oregon and Washington.

The DEIS (page I-10) states: "A principle USDA goal is to assure an adequate supply of high quality food and wood fiber and a quality environment for the American people." It also states: "the best long-term strategy for management of spruce budworm population is through silvicultural treatment and prescribed fire" (page I-3). While this may be true, we would like to specifically point out that "silvicultural practice consists of the various treatments of forest stands that may be applied to maintain and enhance their productivity" (Smith, 1962, p. 1). Thus pest control is, by definition, a silvicultural practice, and the use of pesticides, whether chemical or microbial, are also silvicultural practices. Recent management and future directions seem to have taken a rather drastic turn away from silvicultural practices. It is encouraging to see the Forest Service returning to fundamental, responsible forest management in the budworm control proposal.

Integrated pest management (IPM), one aspect of silvicultural practice, is defined as an ecologically based approach that includes the following types of activities: monitoring, prevention, suppression, and evaluation (DEIS, page M-1). Note that suppression, including chemical treatment, is to be considered as an integral part of IPM.

The DEIS (page I-9) noted that a "key element in the Washington Forest Practices Act is the emphasis on flexibility and site-specific prescriptions". This is indeed the absolute "key" to all silvicultural practices. It is this flexible,

site-specific prescription that should guide any budworm control project. Limiting the silvicultural alternatives to one action alternative would constitute poor stewardship of the resource entrusted to you. Thus we commend you for selecting Alt. D as one of your preferred alternatives and petition you to continue to emphasize the flexibility and site-specific prescriptions included in Alt. D.

We concur with your assessment of other alternatives considered but eliminated from detailed study - e.g. sterile males, parasites, pheromones (DEIS, page II-1) except that you have not fully reviewed other more effective, more toxic alternatives. Please note, that by eliminating registered chemicals outside the DEIS documentation, you comparatively make the "middle of the road" carbaryl alternative appear to be the "worst" alternative of those considered. In actuality, the carbaryl chemical alternative is the "best" of the available chemical alternatives under consideration.

CURRENT PROPOSAL

Alternatives B, C and D predict a need for two treatments on recently infested units to effect adequate protection until the outbreak collapses (DEIS, page II-3). This projection seems to be based on the unjustified, undocumented assumption that: (1) resurgence will take place; and (2) the population collapses, regardless of treatment, in exactly 10 years. Neither have been satisfactorily documented for carbaryl. In fact, the DEIS actually documents the opposite. "No resurgence was noted for the projects using carbaryl in the late 1970's" (DEIS, page IV-9).

We contend, when properly used for budworm control, there should be only one carbaryl treatment. If a second treatment became necessary (which should be unlikely) it should not occur until two or three years after the initial treatment.

In addressing the foliage protection objective of budworm control that is typically used in the East, the DEIS (page IV-9) notes: "This strategy may result in more sublethal effects than the population reduction strategy used in the Northwest and considered in this analysis". In light of this, there should be minimal or no expectation of a development of tolerance to carbaryl as noted on page II-4, #2, Alt. C (DEIS). The USFS plays on this hypothetical development of tolerance to detract from the true "value" of carbaryl and to downplay the real advantages of carbaryl over B.t. as a control method. We find this hypothesis to be unfounded and undocumented, particularly under circumstances present in the Northwest with budworm control.

The lack of differentiation is continued on page IV-9 (DEIS) when it noted that it is generally considered difficult for insects

to develop resistance to microbial insecticides. This statement lacks documentation (as so many others do also). In fact, the only documentation given is for the opposite - a development of resistance (DEIS, page IV-9).

We contend that the USFS is attempting to divert the attention from the beneficial aspects of carbaryl by stating: "The application of sublethal dosages of carbaryl may stimulate budworm populations and contribute to the resurgence of vigorous populations" (DEIS, page II-6, #7, Alt D). Why would you recommend using sublethal dosages? Use 1 pound a.i./ acre carbaryl, as directed on the label and recommended by the manufacturer, and get control of the pest!

With the documented inconsistent results of B.t., the statement that resurgence and reinvasion are not anticipated (DEIS, page II-4, #2, Alt. B), is lacking in credibility, particularly in light of the Alt. C and D statements that resurgence is a potential problem. We find the analysis of efficacy to be lacking support for these statements. The statements are undocumented and highly biased against carbaryl.

GENERAL IMPACTS OF CARBARYL

We find it terribly misleading, and contrary to facts presented in the DEIS, to read that carbaryl "may produce significant impacts to some resources" (DEIS, page II-4, #3, Alt. C). Documentation fails to justify "significant impacts" except on insects. We find the difference between this statement and that of Alt. D to be highly prejudicial and inappropriate.

Similarly misguided statements can be found elsewhere throughout the DEIS. Page IV-43 indicates that there are three areas of potentially significant adverse effects: human health risks; environmental effects on fish, wildlife, domestic stock and nontarget insects; and economic effects. Page II-7, #8, Alt C refers to carbaryl as the " highest risk to human health", when it more appropriately should read "presents a greater, but still minimal, risk to human health".

The documented facts of the matter differ, however.

"Studies have shown no adverse effects at application rates at least two times that of the rate proposed for the Forest Service spruce budworm control program (0.5 lb a.i./acre)" (DEIS, page IV-15). Although the application rate referred to is in error, the statement still applies to the current situation, whether based on 0.5 or 1.0 pound/acre.

The DEIS notes that the way in which exposures are estimated and risks evaluated in the risk assessment tend to exaggerate the real risks (DEIS, page F-3).

> "This 10 times 10, or hundredfold, uncertainty benchmark means the laboratory NOEL dose reduced 1 hundredfold would normally be considered an acceptable dose for chronic exposure. ... No member of the public is likely to receive as high a dose as estimated in this risk assessment. ... In the estimates of public doses no insecticide degradation on surfaces or in food and water was assumed to occur, and the public were not assumed to wash themselves or their food items after a spraying" (DEIS, page IV-31).

While this analysis may be required by law, the USFS interpretation of such minute risks as "potentially significant" (DEIS, page IV-43) seems a bit exorbitant.

In fact, the DEIS states that none of the realistic or extreme wildlife doses of carbaryl exceed the EPA risk criterion of 1/5 LD50 (DEIS, page Q-5), and that even when considering the cumulative effects on wildlife, any impact would be indirect, and the effects are probably not substantial (DEIS, page IV-18).

In addition to the lack of any realistic risk to man or wildlife, carbaryl is not seen as a significant threat to the beneficial insects. "Carbaryl ... should have only minor effects on natural enemies. Populations are expected to recover to exert their controls in time to prevent resurgence" (DEIS, page IV-10). "A fairly rapid reestablishment of these beneficial insects by immigration from areas surrounding the treated area can be expected since little residual effect of carbaryl exists several days after spraying" (DEIS, page IV-17).

CARBARYL IMPACTS ON AVIAN SPECIES

When reporting of the impacts on insectivorous birds and mammals, the DEIS (page IV-11) notes that it is not known whether the total predator populations respond proportionately to increased budworm numbers, or whether individuals are drawn into an area by greater foraging opportunities.

The DEIS then continues to promulgate various undocumented speculations, such as: "Doane and Schaefer (1971) suggested that the reduction in insect populations may reduce the avian food chain in a sprayed area and cause displacement and lowered survival of avian species" (DEIS, page Q-3). This statement is speculative on their part and not documented with scientific fact. This, among others, is being used repeatedly by the environmental community as fact. This practice of speculating, and reporting the speculations of others has no place in this analysis or this document. The USFS is contributing to the environmentalists liberal "interpretation" by reporting such speculation.

We question the difference in impact of a sudden artifical collapse of an insect population due to suppression efforts versus

the sudden natural collapse of an insect population due to natural causes.

IMPACTS OF CARBARYL ON FISH AND AQUATIC INSECTS

The DEIS (page Q-4) cites a study by Burdick et. al. (1960) which states: "There may be a 50- to 100-percent reduction in aquatic insect populations in treated streams and ponds." It fails to note whether this would be the result of direct overspray or drift into buffered streams though. The DEIS (page Q-6) later concludes, however, that no significant adverse effects are expected from direct spraying of a pond at worst case rates for carbaryl.

The DEIS correctly notes that not all the reductions in invertebrate density which occur within the spray area can be attributed to the application of Sevin. Because insect densities change naturally as adults emerge and young hatch, spray-related changes must be distinguished from natural ones (DEIS, page H-5). It also points out that because the reproductive potential of insects is high, it is unlikely that reductions in biomass would persist (DEIS, page H-6).

When discussing the impacts of carbaryl on fish, the DEIS mentions two key points. One, fish recovery from mild Sevin intoxication in the stream should be rapid (DEIS, page H-7). And two, it would be difficult to predict what effect, if any, the reduction in aquatic insects could have on fish growth (DEIS, page H-6).

IMPACTS OF B.t.

The DEIS (page N-3) mentions that "beneficial effects of B.t. applications may be carried over to subsequent years, however, no research has been conducted to fully document or explain their occurrence." First, these "beneficial effects" are not even addressed, and second, this is an admittedly undocumented, undocumentable premise, and has no place in a document such as this. This sort of gross speculation in an EIS does not comport with the requirements of NEPA and NFMA for informed and accurate analysis and dicision making.

IMPACT OF THE DO NOTHING ALTERNATIVE

The USFS analysis of the impacts of the "do nothing" alternative is tremendously lacking in believability. The impact is summarized in the DEIS (page II-4; #3, Alt. A) by stating that the alternative would not produce adverse impacts. Following this statement, however, numerous significant impacts were noted for this alternative (e.g. visual quality, fire, wildlife, timber).

The DEIS (page III-9) misleads the public to believe that some wildlife populations will increase as forested lands return to early successional stages, and those that thrive in older forests will decline. It fails to report, however, that allowing the budworm to run its course will create neither early successional stages nor older forests. What it will create is a heavily damaged forest, more susceptible to secondary attack by other insects and diseases.

The DEIS (page IV-6) refers to an "extreme case" where "tree mortality amounted to 39 percent of the total number of trees per hectare", but concludes that "mortality was not considered a significant effect of budworm defoliation when looking at the infestation area as a whole." The DEIS later predicts that top-kill occurs on approximately 80 percent of the host trees, but only around 10 percent of the total tree height will be killed from moderate defoliation for 10 years (DEIS, page G-6). How can the USFS interpret this insignificant mortality and minimal top kill as being enough to return the forests to early successional stages?

Boise Cascade believes that the proportion of total height killed (DEIS, page G-6) is terribly underestimated. Casual observations of stands in the Simcoe infestation indicate that after only four years of defoliation, mortality is sometimes significant (particularly among previously healthy, thrifty regeneration), and that top kill in moderately defoliated areas would probably be closer to 30 percent than 10 percent. While the observed damage is much more significant than the predicted damage, we believe budworm alone is not enough to return the forests to early successional stages. Secondary insects and diseases, however, may bring about much more significant mortality, which apparently has not been considered in the DEIS.

The DEIS predicts an overall net loss of about 933 board feet per acre (DEIS, page IV-39). It earlier indicated that salvage operations to produce "logs for manufacturing" would be pursued (DEIS, page II-4, #1, Alt A). Is the USFS going to salvage log the entire "general forest" area each year beyond the fifth year of the infestation to capture mortality losses? What are the economic impacts of such a change in the harvest mix, volume per acre and quality? What are the impacts of secondary insects and disease.

OPERATIONS

The DEIS erroneously mentions the application rate for carbaryl on several occasions (DEIS, pages IV-15, IV-22, Q-2). Upon checking with Don Bilyeu of the USFS RO in Portland, we were assured that the intended application rate, and that used for analysis purposes, was 1.0 pound a.i./acre.

The DEIS also erroneously implies in numerous places (e.g. page Q-5) that "sites are normally treated once per year". We at Boise Cascade see no need, and have no intention of treating once per year. Once per decade is even out of the question on much of the infested lands. Statements such as these create unnecessary alarm among the general public.

Finally the DEIS (page M-1) notes that post suppression activities include monitoring and post treatment evaluations to determine the effectiveness and efficiency of suppression efforts. We find the USFS methodology of effectiveness and efficiency evaluation to be totally deficient. Many of the recent "operational" treatments were actually further tests to "prove" the usefulness of B.t. for controling budworm. Data necessary to effectively document the differences between B.t. and carbaryl applications could have been collected. The data presented on B.t. applications to date, however, seems to show only what the USFS wants to show, but lacks the details necessary to make any scientific or statistical evaluation. We specifically question what the prespray population counts were on the various units, and the population densities on control plots at prespray and postspray time intervals. Efficacy comparisons cannot be determined from the data available in the DEIS.

QUESTIONABLE DATA / OBJECTIONABLE COMMENTS

Following are several areas where questionable data was presented or objectionable comments were made. These are in addition to those already referred to in the comments above.

When referring to prespray and postspray fish abundance, the DEIS (page H-3) notes that increases ranged from 7 to 19 percent. It continues, however, noting that CPUE increased 115 percent at Site 7F and 91 percent on the control stream. What is the derivation of these numbers? Is it correct?

The DEIS (page H-4) states that it would not be correct to say that Dr. Post concluded "that survival of the fish in the Warm Springs River system was not significantly affected by spraying." This statement implies that the opposite would be correct. It also is not correct, however, so the entire reference to the statement should be deleted in the Final EIS. Inferring conclusions from researchers' work is not an appropriate practice for this document.

In referring to the efficacy of B.t. versus carbaryl, the DEIS states: "From the preceeding it is apparent that under the conditions of these projects there is no practical difference in the short-term population reduction efficacy of carbaryl or B.t." (page N-2). This is NOT apparent! Further documentation, including the statistical analysis of significance, would be necessary before such a summary could be made.

Finally, the DEIS (page N-3) concludes: "Carbaryl is a broad-spectrum insecticide ... as well as relatively long persistence on forest tree foliage". Relative to what? Referring to carbaryl's persistence as "relatively long" is inappropriate, even in the context given.

SUMMARY COMMENTS AND ACTIONS REQUIRED IN THE FINAL EIS

1. If the USFS intends to narrow the preferred alternatives down to one, Alternative "D" is the best of the preferred alternatives. It provides the flexibility and site specific adaptability that is required for the proper practice of silviculture. It permits the choice between the best of the silviculturally and environmentally approved tools for spruce budworm management. It fulfills the "USDA goal to assure an adequate supply of high quality food and wood fiber and a quality environment for the American people" (DEIS, page I-10). It does not require that all non-sensitive areas be sprayed with carbaryl, but allows the flexibility to use the best tool according to the site-specific circumstances.

2. The Final EIS must show the correct application rate of 1.0 pound a.i. per acre for carbaryl. Using any less would be poor stewardship.

3. Your analysis and dismissal of other chemicals and other means of control (e.g. pheromones, sterilized males, parasites) seems more than adequate, except a realistic analysis of the range of chemical alternatives is lacking. You initially state that the scope of this decision is the treatment of the current outbreak. We concur with this decision. The long-term management of spruce budworm will rest in silvicultural practices (e.g. thinning, fertilization, prescribed fire, species control) that are more appropriately addressed in the forest plan or individual site specific plans. The process that made these stands susceptable to budworm damage occurred over 40 to 80 years. The long-term solution will take an equal amount of time to implement. Until that time, the USFS must remain committed to the full range of IPM, including "monitoring, prevention, suppression and evaluation" (DEIS, page M-1).

4. While you manage to mention every negative speculation and interpretation of data regarding carbaryl, you fail to deal sufficiently with the positive implications. Carbaryl is fully registered for spruce budworm control in the west and "studies have shown no adverse effects at application rates at least two times that of the rate proposed for the Forest Service spruce budworm control program" (DEIS, page IV-15).

5. Your documentation of the negative impacts of carbaryl on avian species is the repetition of primarily speculative comments and are not based upon fact. Such speculations should be deleted from the Final EIS.

6. The only documented impacts of carbaryl are on terrestrial insects (primarily the target of the control operation) and aquatic insects (but only in the case of uncontrolled drift or accidents). We feel there are adequate control methods in place to minimize or eliminate the risk of drift or spills into streams. No method of control is absolute on its target specificity. In order to control the budworm, some non-target insect species will also be impacted. "A fairly rapid reestablishment of these beneficial insects by immigration from areas surrounding the treated area can be expected since little residual effect of carbaryl exists several days after spraying" (DEIS, page IV-17).

7. Direct suppression should not be looked on as a "last resort" but as an integral part of IPM! Arbitrary elimination of one aspect of IPM is the ultimate elimination of IPM in its entirety.

8. The environmental community's statement that "spraying is not a solution but an exacerbation of the problem" is totally ridiculous. That would be comparable to our children's immunizations and our own medical care as an exacerbation of our inevitable death. Just because something is destined to die eventually is no reason not to tend, care for, and manage it during its time on earth.

9. While we would all rather concentrate our dollars and efforts on reforestation, ignoring the needs of existing productive stands would be a gross act of negligence on the part of the USFS.

10. Consideration should be given to secondary insect and disease attack during the site-specific analysis and justification for actual control projects.

11. The mortality and top-kill figures depicted on page G-6 (DEIS) should be examined and updated, particularly for site-specific economic analysis.

12. A statistically documentable analysis of the efficacy of B.t. should be presented in the Final EIS.

13. Any Environmental Analysis for site-specific suppression measures should be clearly limited to applying the decision of this document, rather than reviewing all available alternatives again.

Overall, we find the document to be adequate in meeting the requirements of NEPA and NFMA, except its analysis of other chemical alternatives. The scope of your decision and its impacts are sufficiently addressed, and do not warrant a supplement to this document.

We recommend you move forward from this point, on behalf of good stewardship of the forest. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Thank you for the opportunity to comment on this critically important document. We look forward to continuing to work closely with you on the control of damage by the Western Spruce Budworm.

Sincerely,

Gary Weiher

Gary Weiher
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REFERENCES

Smith, David M. The Practice of Silviculture, Seventh Edition. John Wiley & Sons, Inc. New York. 1962.

USDA Forest Service PNW Region. Draft Environmental Impact Statement, Management of Western Spruce Budworm in Oregon and Washington. 1988.

December 16, 1988

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Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone filfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

2. The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These references should be corrected to read 1.0 lb. a.i./acre as Don Bilyeu has indicated it was intended to be. The use of 0.5 pounds would be contrary to the manufacturer's recommendations and the historical findings of spruce budworm control in the West.

3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

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Regional Forester

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Mr. James F. Torrence
Regional Forester, PNW Region
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Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

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Regional Forester

Bruce K Beckett
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Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone filfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

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3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

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Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

RECEIVED
DEC 23 1988

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DEC 2 2 1988
Regional Forester

Roger Goff
Signature

ROGER GOFF
Name

1413 S. 6th AVE.
Address YAKIMA WA 98902

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000085

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone filfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

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Thank you for the opportunity to comment.

Sincerely,

Michael N Pieti
Signature

Michael N. Pieti
Name

712 N. 7th St Yakima, Wa 98901
Address

RECEIVED
DEC 20 1988

RECEIVED
DEC 22 1988
Regional Forester

December 16, 1988

000086

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

Sherry A. Scott
Signature

Sherry A. Scott
Name

503 N. 24th Ave
Address YAKIMA, WA 98902

RECEIVED
DEC 23 1988

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DEC 22 1988
Regional Forester

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000087

Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

David A Oldham
Signature

David A Oldham
Name

186 W Hutsinson Rd, Selah, WA
Address

RECEIVED
DEC 20 1988

RECEIVED
DEC 22 1988
Regional Forester

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000088

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Thank you for the opportunity to comment.

Sincerely,

Harlan M Berger
Signature

Harlan M Berger
Name

803 So. 31 Ave
Address Yakima, Wa. 98902

DEC 20 1988

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DEC 2 2 1988
Regional Forester

December 16, 1988

000089

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

Gerald L. Pyle
Signature

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DEC 23 1988

RECEIVED
DEC 22 1988
Regional Forester

Gerald Pyle
Name

711 [illegible] Rd Selah Wa
Address

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000090

Dear Mr. Torrence:

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Thank you for the opportunity to comment.

Sincerely,

Sherri Pond
Signature

Sherri Pond
Name

4873 S. Naches Rd
Address

RECEIVED
DEC 20 1988

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DEC 22 1988

December 16, 1988

000091

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

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Sincerely,

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DEC 22 1988
Regio

Signature

Howard Jackson
Name

209 N. 63rd Ave. Yakima, WA 98908
Address

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

000092

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Sincerely,

RECEIVED
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DEC 22 1988
Region

Signature

Allen F Beaudry
Name

714 No. 4TH. ST. Yakima, Wa. 98901
Address

December 16, 1988

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DEC 22 1988

Regional Forester

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

RECEIVED

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Thank you for the opportunity to comment.

Sincerely,

To change a program that has been proven by time and abandon a usefull tool in forest management merely to appease a small group of vocal idealist does no service to the silent majority who benefit from proper management.

Willis A Cawley Jr.
Signature

Willis A Crawley Jr.
Name

1003 Pleasant-Yakima, WA 98902
Address

chairman NWTWRC
President Local 2739

Weyerhaeuser

Tacoma, Washington 98477
Tel (206) 924 2345

December 20, 1988

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DEC 22 1988

Regional Forester

Mr. James F. Torrence
Regional Forester
U.S. Forest Service
319 S.W. Pine, P.O. Box 3623
Portland, Oregon 97208

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DEC 20 1988

000094

Dear Mr. Torrence:

Re: Spruce Budworm DEIS

Weyerhaeuser Company has previously submitted comments to the Forest Service during the scoping process of developing alternative actions to address the current spruce budworm epidemic. We are concerned not only with the management of the current outbreak, but also with the public review process leading to the final environmental impact statement. There is no question about the need to effect a timely and aggressive level of control. The Forest Service appears to have done an excellent technical job of evaluating alternative control methods, environmental tradeoffs between the two preferred methods and evaluation of health risks.

The DEIS identifies two preferred alternatives, with Alternative B (B.t. only) essentially included in Alternative D (B.t. and carbaryl). Weyerhaeuser recommends that Alternative D be adopted as the prescribed action in the FEIS. The analysis of Alternative D essentially includes all of the environmental and risk assessments included in Alternative B. We will focus our comments on Alternative D. We feel there is no reason to consider further Alternatives A and C because neither would be totally effective and environmentally sound. After reviewing the analysis and discussion, it is somewhat disconcerting that the Forest Service listed two preferred alternatives; presenting two preferred alternatives only serves to make the evaluation of alternatives more difficult.

Our specific comments follow:

Protection Around Wilderness Areas (Summary 18). Management of forest pests and fire adjacent to Wilderness areas has at times increased the risk to adjacent timber and other nonwilderness resources above levels they would have been exposed to had control methods been applied over the entire area. Because Wilderness areas will remain untreated, it is critical that Forest Service land managers be prepared and have authority to use either B.t. or carbaryl on a site-specific basis. The case-by-case analysis referred to in the DEIS must not result in the need for a supplemental EIS prior to initiating a control action, but rather a standard environmental assessment that is directly tiered to this programmatic EIS. This relationship must be clearly spelled out in the EIS.

Timber Growth Loss (IV 5-7). Table I-II indicates an observed infestation area visibly defoliated between 1982-87, unprecedented in recent years. Although there is no way to calculate growth loss until after the current epidemic subsides, recognition of a potential 2.9 percent loss of predicted growth from a 10-year outbreak is significant. Although infestation may lead to delays in silvicultural treatments, when the outbreak is controlled, practices should be intensified to improve stand quality and recapture both value and growth.

Wildlife and Aquatic Concerns (Appendix Q). Discussion of the risks to wildlife and aquatic species indicates Alternative D adequately addresses exposure risks. The indicated risks associated with B.t. make it an excellent tool for application in riparian areas or other sensitive habitats. The combined use of B.t. and carbaryl provides the opportunity to treat the entire infested area within acceptable EPA risk levels.

Although Weyerhaeuser supports maintaining a buffer adjacent to water where no carbaryl would be applied, it is worth noting that, "no significant adverse effects are expected from direct spraying of a pond at worst case rates for carbaryl" (Q--6). "Aquatic species are not considered to be at risk from B.t. applications..." (Q--6).

It is encouraging that an effective control operation can be conducted using a combination of carbaryl and B.t. without elevated risks to wildlife or aquatic species.

Conclusions:

Weyerhaeuser strongly encourages the Forest Service to adopt Alternative D as the final spruce budworm management alternative. In doing so it should,

--establish field tests to demonstrate the effectiveness of B.t. compared to carbaryl so any future EIS can be modified accordingly,

--identify sensitive areas where carbaryl will not be applied, particularly wetlands and head water areas,

--monitor the effects of carbaryl on "other resources", i.e. small mammals, invertebrates, and birds to determine if populations are adversely affected,

--identify the situations where carbaryl is the only effective control method.

In closing, the DEIS presents a compelling case for the combined use of both carbaryl and B.t.. Use of these tools will give the Forest Service the latitude to hit hot spots with carbaryl and apply B.t. in the more sensitive situations identified in the DEIS. We look forward to a successful and aggressive spruce budworm control program, coupled with a monitoring effort that will further establish the effectiveness and environmentally sound use of both treatments.

Sincerely,

D. W. Mumper

D. W. Mumper
Manager, Timberlands
Resource

bek
cc: J. P. McMahon - CH 1M29
T. A. Terry - Centralia 13
R. Bailey - Northwest Forestry Association
M. R. Dick - Washington Forest Protection Association

NORTHWEST COALITION for
ALTERNATIVES to PESTICIDES
P.O. BOX 1393 EUGENE, OREGON 97440 (503) 344-5044

000095

December 22, 1988

James F. Torrence
Regional Forester
Region 6 Forest Service
PO Box 3623
Portland, OR 97208

RECEIVED
DEC 30 1988

Dear Jim:

Enclosed are NCAP's comments on the Draft Environmental Impact Statement for spruce budworm control. We have pointed out some major deficiencies that exist in the draft document, and urge the Forest Service to issue a supplement for the EIS that analyzes a long-term approach to contolling this forest insect.

The Forest Service can do better than just killing bugs.

Hope you have a joyful holiday.

Sincerely,

Norma Grier

Norma Grier
Executive Director

Enclosure

NORTHWEST COALITION for ALTERNATIVES to PESTICIDES
P.O. BOX 1393 EUGENE, OREGON 97440 (503) 344-5044

COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT
MANAGEMENT OF WESTERN SPRUCE BUDWORM
IN OREGON AND WASHINGTON

December 22, 1988

Submitted by: Norma Grier and Mary O'Brien

The Northwest Coalition for Alternatives to Pesticides has reviewed the Draft Environmental Impact Statement (DEIS) for Management of Western Spruce Budworm in Oregon and Washington and submits the following comments:

1. The scope of the DEIS is too narrowly defined, in defiance of the statutory mandates of the National Forest Management Act (NFMA) and the National Environmental Policy Act (NEPA).

NFMA has land management as the core of the Act. "The land management plan and supporting functional plans must be brought together in one place in one document of a series of documents so they are more readily accessible to the public."[1]

The stated national policy in NEPA (1969 as amended) recognizes the profound impact of human activity on the interrelations of all components of the natural environment and recognizes the critical importance of restoring and maintaining environmental quality. "Federal agencies shall to the fullest extent possible...integrate the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively." (40 CFR 1500.2)

As indicated in NCAP's scoping comments, both NFMA and NEPA clearly point to the need to develop programs that address larger management implications for the action proposed by the agency. "The point of both statutes is to avoid too narrow a focus."[2]

Despite these mandates and scoping comments, the Forest Service has chosen to limit the decision for the EIS to "dealing with the question of what should be the strategy for managing the current outbreak." (page I-3)

Unquestioningly, the most troublesome aspect of this DEIS is the lack of long-range management commitments on the part of Region 6 Forest Service. While arguing that lasting solutions to spruce budworm problems will be achieved with long-term management through silvicultural treatments and prescribed fire,

the DEIS states the agency does not currently have the operational capacity to make long-term strategic decisions.

As indicated in NCAP's scoping comments, this statement is in sharp contrast to the opinion held by the authors of a Canadian/United States (CANUSA) publication. They state that despite the complexity of forest stands and environmental factors, "we understand enough about them to make management decisions detrimental to the budworm and other pests."[2] There are other resource material available to managers who need to make decisions based on the health of the whole stand, rather than on the presence or absence of budworm larvae.[3,4]

Interestingly, the text of the 1988 Environmental Assessment written for the 1988 direct suppression program discusses Integrated Pest Management (IPM) and the benefits of such an approach more specifically. The DEIS relegates this discussion to Appendix M in the back of the document. As a result, no IPM alternative is to be found in this DEIS.

2. <u>By avoiding development of a comprehensive spruce budworm management policy either in the DEIS or in Forest Plans, the Forest Service shirks its legal responsibility to develop such a program.</u>

The Forest Service claims that comprehensive, long-range pest management programs will be developed and articulated in the Forest Plans. As pointed out in NCAP's scoping comments, the Forest Plans usually claim that insect control programs, such as the spruce budworm, will be analyzed in an insect-specific EIS. As a result, neither document deals with comprehensive management issues.

NCAP has looked at the Umatilla, Malheur, Ochoco, and Wallowa-Whitman forest plans to determine the extent that the planning process addresses the long-term issues. These are all forests that have had a history of insect outbreaks and have recently experienced spruce budworm populations. The Umatilla proposed land management plan and Draft EIS is the only forest that comes close to addressing these issues. The other forests' discussions range from nonexistent to a paragraph or two.

The agency cannot have it both ways. Adequate information is available to make a commitment and set direction for managing forest lands to reduce susceptibility to forest insects.

The recently-issued vegetation management EIS sets forth a policy that commits to preventing the conditions that are problematic, accurately documenting the need to treat a problem, and preferring non-chemical treatments over chemical ones. Not all plant problems are solved in the EIS, but the document clearly commits to a comprehensive stategy for dealing with

vegetation problems. Forest managers will find clear guidance in the policy when making site-specific prescriptions.

Since the Forest Plans do not include this information, the spruce budworm management EIS is the proper place for articulating Region 6's programmatic management commitment. This would provide uniform, publicly-reviewable guidance for the Region on management of an important forest insect.

3. <u>The DEIS fails to analyze all reasonable alternatives, as required by the National Environmental Policy Act.</u>

None of the alternatives analyzed in the DEIS is a program to manage spruce budworm. Rather, each alternative is designed to simply kill bugs. The proposal is to treat the symptoms of a problem and ignore the causes.

In our scoping comments, NCAP asked the Forest Service to develop an alternative built on the principles of integrated pest management (a systems appoach to management, rather than a pest-specific appoach).

The systems approach is reasonable. Forest Service acknowledges the need and benefits of such an approach. The agency needs to develop this alternative and analyze it along side the other alternatives in a supplemental EIS.

4. <u>Forest Service should issue a supplement to the EIS and describe a long-term management approach that includes recognition of the need for short-term management on selected sites (e.g., visual and recreational sites).</u>

A long-term management approach that recognizes short-term needs is categorically different from the alternatives that are currently described in the DEIS. An alternative describing and analyzing a long-term approach cannot be pasted on top of the alternatives presented in the DEIS. Forest Service needs to issue a supplemental EIS (SEIS) that justly analyzes this alternative.

5. <u>Forest Service needs to select one preferred alternative.</u>

The DEIS endorses two preferred alternatives: Alternative B is a Bt program and Alternative D is a carbaryl program that uses Bt in sensitive areas (page IV-18). The difference between these two is that one kills all lepidoptera that are in a sensitive life stage and the other kills all forest insects.

The Forest Service cannot say much that is good about carbaryl in their analysis. Yet for some unexplained reason, the agency likes carbaryl. The only explanation available to NCAP is the statement made at the spruce budworm workshop in Portland on December 15 by Rick Brathovde of Boise Cascade that the private

forest industry likes carbaryl better. This is a foolish position for the Forest Service to find itself in. Forest Service needs to make their best collective thinking clear to the public on why one management approach is preferable to another. The current DEIS fails to do this.

The SEIS needs to select one preferred alternative from among the short-term strategies and the long-term management approach that will be analyzed for spruce budworm control.

6. The Region 6 DEIS does not examine alternatives being practiced in surrounding regions where large-scale suppression programs are no longer being conducted.

The DEIS' description of the history of spruce budworm suppression points to the futility of large-scale spray programs (Page I-4 and Appendix N). Regions 1, 4, and 3 have all stopped massive spray programs. Good thinking has gone into developing long-term approaches to the spruce budworm problems. Region 6 should look to see what alternatives have been proposed in these surrounding regions.

7. The expected lifespan of the spruce budworm EIS needs to be clearly identified.

The DEIS claims that the analysis is intended for killing spuce budworm in the short run during the current outbreak (page I-3). The current outbreak was first noted in 1980 (page I-4). Outbreaks typically last from 6 to 10 years (page I-4). A reasonable person would deduce that the DEIS would apply to programs at the maximum for two more years.

However, an outbreak in the Rocky Mountains has persisted for three decades.[5] If Oregon and Washington's outbreak also persists in the manner that the Montana outbreak has persisted, this document could be a decision document for many decades. Such being the case, there is every reason to develop a long-range plan for addressing spruce budworm management.

Outbreaks appear to be encouraged by abundant food supply and favorable weather. They appear to decline due to starvation and unfavorable weather (page IV-8). Clearly no one really knows how outbreaks start, develop, persist, and crash. It is unclear to NCAP when an outbreak starts and when it stops. Consequently, this document could be invoked to support massive spray programs over extended periods of time without being accountable to the public for developing a program that moves away from, ineffective, short-term, stop-gap measures.

8. The EIS needs to better clarify the biological and economic significance of timber growth loss.

Growth loss is described as reduced height and diameter growth rates. The DEIS cites several studies to indicate reductions in growth or predicted growth rates (page IV-5). It's as if budworm defoliation accounts for all reductions in growth, ignoring growth reductions that should be attributed to major factors like drought conditions. Looking over the entire life of a stand of trees, growth reduction during a decade of less than optimal growing conditions (i.e., drought) may not be significant or avoidable.

The DEIS calculates growth loss if diameter or height growth is less than the predicted average for that tree (page IV-5). This is unacceptable. Average growth predictions are derived from some growth being better than average and some being less than average over time. Forest Service cannot ignore that a growth rate has peaks and troughs. Attempting to eliminate the troughs in growth rate by spraying large acreages for increases in spruce budworm populations that correlate with years of drought is senseless.

Waring and Schlesinger point to improved growth rates for defoliated trees. "In a few long-term studies, surviving trees have, after a delay, shown improved growth rates that continued for some decades following extensive defoliation."[6]

No documentation is given for the statement that rescheduling pre-commercial thinning "probably" will lengthen the rotation age of the stand (page IV-5). Undocumented guesses that delayed thinning probably will lengthen rotation age do not belong in the EIS.

The DEIS needs to separate what, if any, growth loss is attributable solely to the spruce budworm from growth reductions due to factors (such as weather) that hinder average annual growth.

9. <u>The wide discrepency in mortality rates and claims of resultant harm need to be adjusted</u>.

A reader of the DEIS is presented conflicting data about mortality resulting from spruce budworm infestations. Apparently, increased mortality in forest stands over the last 20 years can be attributed to insects (page III-4). Mortality figures vary: less than 3% while maximum total defoliation was no greater than 25% (IV-3); extreme mortality of mostly smaller, suppressed trees was at 39% (page IV-6); mortality was 4% in Washington (IV-6); mortality on the Malheur ranged from 0-18%, and in heavily defoliated areas from 6-23% (IV-6); in heavy defoliation, hundreds of acres experience mortality in excess of 90% (IV-25); and, most defoliation is less than 100% and mortality is less than 3% (IV-19).

Waring and Schlesinger discuss patterns of mortality in their book. Even where pathogens kill dominant as well as supressed trees and 30% of the stocking of the stand is lost, stand growth rates can be maintained over a decade.[6] When mortality rates from windstorms are averaged over a 50 year period, the rates are amazingly consistent, averaging 1% per year. Granted, these examples are not all insect examples, much less spruce budworm examples, but the point is clearly made that the presence of some dead trees is not cause for alarm. Economic impacts must be assessed on the entire stand over periods of time longer than the outbreak period.

10. Economic costs need to be specifically identified.

The DEIS fails to provide the public accurate costs of the proposal. It appears that the cost equals the dollar amount of the Congressional appropriation.

There is no indication of the costs for insecticide, application, monitoring, planning, etc. that would be part of the program. Consequently, the alternatives cannot be compared.

Cascade Holistic Economic Consultants conducted an economic review of spruce budworm management after the 1983 spray program (see Attachment /). The report raises serious questions about the costs and benefits of spruce budworm spray programs. Many of these issues (including assumptions in the analysis of growth, detrimental role of the budworm, desireability of budworm-susceptible stands, costs of the program and the value of the timber resource) are still at issue in this EIS.

The DEIS claims that there would be an irretrievable loss of timber production associated with the no action alternative of 1.5 billion board feet over the next 70 years (IV-39). The DEIS continues with the vague statement that "various portions of the estimated 1.5 billion board feet volume at risk may be protected by investing various amount of funds in a supression program." (IV-39). The public needs to know just what we are expected to pay for what benefit. Vague allusions to an amorphous program are unacceptable. The Forest Service needs to get specific!

11. The effectiveness (and hence benefits of the program) need to be based on maintaining overall health of forest stands over time, not on the numbers of bugs an insecticide kills in one season.

Since defoliation is not always detrimental,[6] basing the measure of program effectiveness on the number of surviving budworm larvae is counterproductive. The DEIS cites figures to indicate the number of larvae per branch tip from the 1988 program (I-5,6). There is no evaluation of the health of individual trees in the forest as an indicator of the success of

the program. More importantly, there is no assessment of the overall health of stands of trees to indicate the success of the program.

Pest-specific programs that are divorced from an ecological, systems approach to addressing pest problems focus on individual insect species. A systems approach to the problem would not put emphasis on one kind of bug.

Interestingly, most of the acreage treated in 1982 and 1983 was defoliated in subsequent years. (I-5) This certainly raises questions about the efficacy of the program.

12. The agency must convey exactly how they will identify areas that are needing treatment.

The DEIS outlines a simple procedure for undertaking an economic analysis (Appendix E) and the standards and guidelines that will apply to the program (Appendix C). There are still two issues that were raised in NCAP's scoping comments that have not been addressed in the DEIS and need to be.

In 1987, 60,000 acres were improperly prescribed for spruce budworm spraying. Apparently, the sites did not even contain host species for the budworm. Forest Service has not indicated how such poor judgment will be avoided in the future.

When sampling for grasshopper populations, several factors encouraged overestimation of the problem. Most notably, inexperienced technicians tend to overestimate pest problems, making the problem appear worse than it really is. If grasshopper populations are surveyed in early instars, the tendency is to overestimate populations by not accounting for normal attrition. Spruce budworm technicians may experience similar problems. Since populations appeared to crash in 1988 regardless of treatments of lack thereof, the problem with misprescriptions is compounded.

13. The DEIS must discuss how children are placed at greater risk from exposure to toxics (including insecticides).

The DEIS fails to address many critical issues about the exposure of children to toxic substances. The attached article by Dr. Beverly Paigen identifies the children's issues that need to be discussed (Attachment 2).

14. Aquatic ecosystems need stronger protection.

The DEIS indicates state law providing for a 60 foot buffer zone next to streams and sensitive areas is adequate. This is ridiculous. According to the Forest Service's own stream monitoring, 100 foot buffers in 1982 and 1983 produced

contamination in well over half the streams that were monitored. A 60 foot buffer provides even less protection.

Forest Service should identify a size for its own buffer zone that it considers adequate to protect aquatic resources and water. Reliance on state buffers is clearly inadequate.

Attached is an article on drift that identifies some of the issues that need consideration in addressing buffer zone needs (Attachment 3).

15. Miscellaneous issues of concern.

a) NCAP was omitted from the list of participants in the Forest Service scoping process. In addition to a face to face meeting with the team leader, NCAP submitted four pages of scoping comments for the team's consideration.

b) Page numbers are missing from Appendix F, making it extremely difficult for commenting purposes.

c) The specialties, expertise and roles of the interdisciplinary team members have not been identified. That would be helpful for the public.

d) In Appendix C, it seems that protesters can be sprayed as long as employees of the agency and contractors are safe and public safety isn't a concern. No one should be directly sprayed in a Forest Service program. There have been too many occasions over the years in which unwitting people have been sprayed during Forest Service programs. Directly spraying people, whether they are perceived as protesters or not, is unacceptable.

e) Please add NCAP to your list of people who would receive the Supplemental and Final EISs.

Carbaryl as an Indiscriminate Poison

1. It is misleading of the Forest Service to say that they will spray carbaryl for spruce budworm because carbaryl doesn't recognize spruce budworm: it basically attacks all insects present in the forest when spruce budworm is sprayed. It is more accurate, then, to say that the Forest Spray intends to spray for all insects in the forest, spruce budworm among them.

The EIS points out that hymenopterans (bumblebees, solitary bees, honey bees), ladybird beetles, and thrips that prey on mites are susceptible to carbaryl. As for aquatic insects, the EIS cites "loss of stonefly species from individual streams and altered generic assemblages for an indefinite period' " (Q-4) Amphipods in ponds in Maine failed to recolonize in some ponds in Maine for 30 months after spraying. (Q-4)

By extension, with some variability in precise effects on certain species, carbaryl will be attacking all orders of insects, all insect populations present under the spray plane. Ecologists have shown again and again, of course, that it is the predator populations that ultimately suffer more decimation than the pest populations from indiscriminate pesticides (see Attachment A, "DDT Substitute" by Ian Nisbet and Dallas Miner, and Attachment B, "Environmental Upsets Caused by Chemical Eradication," by Paul DeBach and Mike Rose.)

But the EIS never discusses the significance of attacking the entire insect spectrum in the forests to get the spruce budworm larvae. The following are considerations of concern:

1. What birds depend on the insects for food and reproductive success in the early summer?

2. What fish depend on the insects for food and reproductive success?

3. What invertebrate predator-prey relationships are threatened by killing the insects?

4. What insect species and populations do not recover easily when populations have been decimated?

Is the Forest Service assuming that the entire insect spectrum present in the forests in June is expendable? The cheerful assumption is that the populations will bounce back (as, demonstrably the spruce budworm will bounce back), but some insects will <u>NOT</u> recover as easily as the spruce budworm.

I recall my doctoral dissertation field work on a site in the San Bernardino mountains of southern California. An onion (*Allium fimbriatum*) endemic to a few sites called "pavement

plains" in the San Bernardino mountains was pollinated almost exclusively by an halictid bee species (Microlictoides sp.) that had never before been identified. The two species had coevolved to the extent that the bee would emerge two or three days after flowering of A. fimbriatum. Two or three days after the last onion plant had gone to seed, the last Microlictoides individuals would disappear for the season. The bee of course depended on laying new eggs each season, as they do not overwinter.

How many systems such as these are threatened by spruce budworm spraying? Until I worked on my dissertation on that site, no one even knew that bee species existed.

Clearly, the Forest Service must consult with ecologists and biologists to present the potential for damage to food networks and inter-organism dependencies when spraying with a broad spectrum insecticide.

The interpretation by the EIS of individual studies regarding attacks on insect and spider assemblages with carbaryl is interesting. In trying to show that spiders will recover, the EIS writes, "As shown in another study, spiders quickly return to treated areas within 3 weeks after spraying (Barrett, 1968)."

In fact, this reference indicates quite the contrary. The study compared vertebrate and invertebrate population effects in a one-acre, carbaryl-sprayed plot of grassland with a one-acre unsprayed plot, both plots surrounded by intact grassland and therefore much more open to invertebrate recruitment than the large acreages to be sprayed in the proposed spruce budworm program. The researcher indicates, "Spiders, which were the dominant predaceous group of arthropods, showed a decline in standing crop in [the sprayed plot] following insecticide application [July 28] and they remained below the [unsprayed plot] level until September [more than five weeks later]." (See Attachment C, "The effects of an acute insecticide stress on a semi-enclosed grassland ecosystem" by Gary Barrett.)

Other findings in this study not mentioned in the EIS included:

(a) The reproductive failure of the cotton rat four weeks after spraying and subsequent replacement and dominance by the house mouse.

(b) A "highly significant decrease in the rate of litter decomposition. It appears likely that the insectricide killed or repelled the microarthropods which are known to be important in the primary breakdown of leaf litter... It appears that pesticides can conceivably adversely affect mineral recycling."

(c) Reduction of density, biomass, and diversity of primary and secondary consumers following insecticide treatment.

(d) Although primary consumers recovered to the control level two weeks following treatment (remember that only one acre was sprayed), "Diversity of the predaceous insect group, on the other hand, was markedly repressed for 5 weeks following treatment."

The researcher notes, "The important point to emphasize is that effects of the insecticide treatment on community organization were detected long after the toxic residue had disappeared." This conclusion is for one sprayed acre. The EIS must address the implications of spraying tens of thousands of contiguous acres.

In terms of selectivity, the use of carbaryl to kill spruce budworm is like using TNT to kill only left-handed children in a crowded school auditorium. Carbaryl has a big market precisely because it will kill all kinds of insect pests, but of course it kills all kinds of insect pests because it kills all kinds of insects.

The EIS must discuss the environmental implications of directly attacking all insect networks present in the forest at the time of the spraying and of indirectly attacking vertebrate species that depend on those insect systems (e.g., for food, pollination, natural control).

The EIS notes that when New Jersey forests were sprayed with carbaryol for gypsy moth, bird populations decreased 55% within 2 weeks after spraying "and showed no recovery during 6 more weeks of monitoring or in the following year during June and July (Appendix F, p. 38). Possible explanations given are reduced food supply, reduced reproduction, and feeding elsewhere. What bird populations are likely to be affected in Oregon and Washington if the cause is reduced food supply or reduced reproduction? It is not appropriate to mention a study such as the one cited in Appendix F, p. 38 and not discuss the implications of that for Region 6 wildlife.

To do this, the Forest Service will need to consult with ecologists, entomologists, and wildlife specialists for an analysis of the inter-species effects of spraying carbaryl. The current EIS focuses almost exclusively on the acute effects to single, representative species and groups and flies directly in the face of a growing scientific literature regarding the interdependencies of organisms in an ecosystem.

NCAP would hope that forest management was getting beyond this kind of sledgehammer behavior. It is increasingly unacceptable to treat the forests in this manner, given our increasing understanding of the interactions within forest ecosystems.

B.t. and Butterflies

Well, how about B.t.? It only attacks the moths and butterflies exposed to B.t. during or following the Forest Service spraying, doesn't it?

The EIS refers to a 1986 study by Jeffrey Miller in Oregon following the use of B.t. in the state's gypsy moth project. The EIS says not to worry about the lepidoptera: "In a study done during the 1986 Gypsy Moth Project in western Oregon, it was found the population of lepidopteran larvae was reduced significantly within 48 days following the last treatment. However, there was no significant difference between populations in the control and treated areas 68 days following the last treatment (Miller, 1986). Considering these combined factors [i.e., Miller's findings; not all lepidopteran species will be at the larval stage at the time; not all phytophagous larvae feed on plants parts exposed to B.t., and not all individuals of susceptible species will be killed], it is highly unlikely that significant long-term impacts upon nontarget lepidopteran populations will occur." (IV-12)

As it turns out, no citation is given in the EIS for the "Miller 1986" reference, but attached is a 1988 article by Jeffrey Miller (Attachment D) which contains conclusions directly contradictory to those "cited" by the EIS.

Miller has monitored Lepidoptera in six paired sample sites (one sprayed plot and one unsprayed plot in each pair) for three years now and has found that caterpillar abundance was reduced for two years after the 1986 spraying, and that Lepidoptera species richness continues to be lower in the sprayed plots this year three years after the spraying.

Miller notes, "The data developed in this study addressed a set of effects on nontarget organisms (spillover impacts) which are pertinent to a number of important issues:

"1) Populations of Lepidoptera serving as biological control agents of noxious weeds may be at risk. A reduction in their population density could result in an increase in the seed set and populations of their host plant. Secondly, under certain conditions, a reduction in caterpillar abundance could negatively affect the reproduction of some birds. Thirdly, rare or endangered species of Lepidoptera could be at risk of extinction if their poulations were restricted to areas encompassed by pest control programs, even those using BT as the control agent."

Clearly, the EIS has not addressed critical issues of biological control, bird reproduction, and extinction.

The EIS notes, "Some nontarget moth and butterfly species, which are in the larval stage at the time of treatment, may be at risk of experiencing population reductions for a year or two." (IV-12)

Relevant to this question of whether broad-scale use of B.t. against all Lepidoptera larvae exposed to B.t. spraying are some excerpts from a chapter by Jeremy Thomas in the Royal Entomological Society of London's 1984 book, The Biology of Butterflies (Attachment E):

"Pollard et al....describe a simple method of transect recording being used to measure relative changes in adult numbers of every species of butterfly on 81 UK [United Kingdom] sites." (p. 335)

"...[M]ost breeding sites [of UK butterfly species] are rapidly disappearing, and where this has not obviously occurred, the long-term trend (as distinct from annual fluctuations) of several butterflies has been downwards." (p. 335)

"...[A]ll species [of butterflies] have proved extremely particular about the niches they occupy, and seemingly minor habitat alterations often result in poor survival of the young stages and/or reduced natality." (p. 337)

"About 85% of [the 55 resident] UK butterflies form closed populations. Apart from [4 species], all that have been studied are reluctant to cross unsuitable habitat." (p. 342)

"Insect populations react rapidly to changing conditions, and losses that are merely considered regrettable at present should be treated very seriously as indicators of a long-term change." (p. 352)

"Time and again in the UK, conservationists and ecologists have tried to guess the answers, but have nearly always been wrong." (p. 352)

None of the points mentioned here have been discussed in the EIS.

Clearly, the EIS writers have not delved into the literature regarding the fragility of population retention among lepidoptera. The EIS must examine the world literature on this topic, must examine Jeffrey Miller's work here in Oregon, must acknowledge the data gaps of the Forest Service (particularly regarding what Lepidoptera are present in the spruce budworm area and what is known of their ecology, abundance, population sizes, etc.), and must make worst case assumptions regarding the cumulative, longterm, and indirect effects of repeatedly knocking back Lepidoptera populations in the areas contemplated for treatment for the duration of the EIS.

Critical to this discussion would be maps which indicate which areas have been treated when with broad-spectrum insécticides over the last several decades. The longterm, possibly irreversible damage we may be doing to insect assemblages in these areas needs to be contemplated.

The indiscriminate killing of inveretebrates by carbaryl and the attack on all Lepidoptera larvae exposed to the B.t. spray imply that the proposed masssive spray program has potentially severe, indirect, and longlasting effects on forest community structure, species, and food networks. These effects have not been examined by the EIS.

Secret Ingredients

The three carbaryl formulations mentioned in the EIS are Sevin Brand 80S, Sevin Brand 50W, and Sevin Brand 4-Oil (Appendix F, p.95). The percentage by volume of carbaryl in these formulations is 80%, 50%, and 4%, respectively. The percentage of secret ingredients, unknown to the public and unknown to the Forest Service, is 20%, 50%, and 96%, respectively.

Any surfactants or other materials used to deliver B.t. will also likely be secret.

There are a number of concerns raised by this (see Attachment F for references):

1. Secret ingredients are added as solvents, preservatives, emulsifiers, surfactants, aerosol propellants, dyes, stabilizers, and anti-volatility agents.

2. Neither the Forest Service nor the public is able to find out what chemicals they are spraying.

3. The full carbaryl and <u>B.t.</u> formulations have not been tested for cancer, birth defects, reproductive effects, or genetic, nerve, or chronic damage.

4. Approximately 800 of the 1,200 secret ingredients in pesticide formulations are of unknown toxicity and might therefore be found to cause any of the full range of toxic effects (e.g., cancer, reproductive effects, immune suppression, birth defects) were they tested in laboratory animals.

The EIS does not discuss these problems, preferring instead to treat their ignorance as bliss (E.g., "The single inert of concern in this analysis, kerosene, has been fully analyzed in the risk assessment." IV-38). The public won't treat their ignorance as bliss and the environment can very well suffer from their ignorance (i.e., any ingredients in Sevin formulations that have never been examined toxicologically are of concern to the public and may cause damage). Therefore, the Forest Service must fully disclose the potentials for hazard and the significance of not knowing what chemicals they are spraying and of spraying chemicals whose toxicity has never been examined.

The definition of inerts given in the Glossary is dangerously false and the discussion of List 3 inerts on p. 130 of Appendix F is totally misleading: "...neither available toxicity data nor a review of their chemical structure shows evidence that would place them in Lists 1 or 2". In fact, List 3 inerts are secret ingredients for which <u>no</u> toxicology data are available.

Carbaryl Toxicology

A number of inaccuracies in the EIS regarding the potential impacts of carbaryl have been raised earlier in litigation regarding the USDA EIS for gypsy moth and the EIS must correct these inaccuracies.

1. The EIS bases its analysis of carbaryl risk to humans on an estimated 10% dermal penetration (Appendix F, p. 81), citing the 1985 USDA EIS for gypsy moth eradication as the reference. In fact, the only peer-reviewed, published study of human skin absorption of carbaryl indicates that 73.9% of carbaryl is absorbed by the forearm and the forearm is one of the least permeable areas on the body (See Attachment G).

2. The EIS does not use the carbaryl NOEL for human kidney function of .06 mg/kg/day, based on an actual human volunteer study nor does it discuss the kinds of symptoms humans have experienced when exposed to public aerial spraying of carbaryl (see Attachment H).

3. Of the human study by Wills (1968), the EIS writes, "Ingestion of a single dose of carbaryl at dosage levels of 0.5, 1.0, and 2.0 mg/kg by two men per dosage level revealed no subjective or objective effects. (Appendix F, p., 21) What the EIS doesn't mention about that study is that a 6-week dose of only 0.13 mg/kg altered kidney functioning for 15 weeks. (See Attachment I).

4. The EIS does not cite studies discussing alteration of sperm head morphology in human workers exposed to carbaryl, alteration of sperm morphology, mobility, and number in rodents exposed to carbaryl, depression of immune response in rabits, or increase in susceptibility of human cells to viral growth following exposure to carbaryl. None of the studies circled in red in Attachment I have been cited or addressed by the EIS.

5. Appendix F is a miserable, shoddy risk assessment discussion for the public. There are no page numbers and no table of contents for it even though it is over 230 pages long. Anyone trying to read it has to wade through analyses of malathion and acephate even though the EIS is not proposing use of either of these chemicals. No analysis is offered of the quality of studies cited and critical studies have been omitted.

A risk assessment must be performed of the use of carbaryl and B.t. that uses quantitative, qualitative, and worst case analysis in order to use quality data, use data that do not lend themselves to quantitation, and considers the significance of suggestive or missing data.

In summary, NCAP finds major flaws in the DEIS for spruce budworm. The scope of the document is too narrowly defined. It is missing a long-range management alternative based on a systems approach that includes some short-term treatment needs. The economic, environmental, and human health impact assessments are deficient and need to be reworked.

The Forest Service should develop a supplemental EIS that includes an analysis and comparison of a long-range alternative, selects one preferred alternative, and makes that document available for public review.

NCAP looks forward to commenting on the Supplemental EIs when it is available.

REFERENCES:

1. USDA Forest Service. December 1976. The National Forest Management Act of 1976. Current Information Report No. 16.

2. Brooks, MH, JJ Colbert, RG Mitchell, and RW Stark. February, 1987. Western Spruce Budworm and Forest-Management Planning. CANUSA, Spruce Budworm Programs-West, USDA Cooperative State Research Service, Technical Bulletin No 1696.

3. Brooks, MH, JJ Colbert, RG Mitchell, and RW Stark. December, 1985. Managing Trees and Stands Susceptible to Western Spruce Budwrom. CANUSA, Spruce Budworm Programs-West, USDA Cooperative State Research Service, Technical Bulletin No 1695.

4. The Integrated Pest Management Working Group. D Brown, SM Hitt, and WH Moir, eds. January, 1986. The Path from Here: Integrated Forest Protection for the Future. Independent report developed as part of the out-of-court settlement in Region 3 Forest Service's spruce budworm spray program.

5. Fellin, DG. 1983. Chemical insecticide vs the western spruce budworm: After three decades, what's the score? <u>Western Wildlands.</u> Missoula, MT. 9(1):8-12.

6. RH Waring and WH Schlesinger. 1985. Susceptibility and response of forests to natural agents of disturbance. <u>Forest Ecosystems: Concepts and Management</u>. Academic Press, Chapter 9.

7. Region 6 Forest Service. July 14, 1987, Review of the 1987 Pacific Northwest Region Western Spruce Budworm Suppression Projects, prepared for Jim Torrence, Regional Forester, Portland, OR.

LIST OF ATTACHMENTS

Attachment 1. Randal O'Toole. 1984. Economic Review of Spruce Budworm Management. Eugene, OR: Cascade Holistic Economic Consultants.

Attachment 2. Beverly Paigen. 1986. Children and Toxic Chemicals. Journal of Pesticide Reform 6(2):2-5.

Attachment 3. Norma Grier. 1988. Why Pesticide Spraying Means Drift. Journal of Pesticide Reform 7(4):6-9.

Attachment A. Ian Nisbet and D. Miner. 1971. DDT Substitute. Environment 13(6);10-17.

Attachment B. Paul DeBach and M. Rose. July, 1977. Environmental Upsets Caused by Chemical Eradication. California Agriculture.

Attachment C. Gary Barrett. Autumn, 1968. The effects of an acute insecticide stress on a semi- enclosed grassland ecosystem. Ecology 49(6):1019-1035.

Attachment D. Jeff Miller. November 1988. Field assessment of a microbial pest control agent on nontarget lepidoptera. Unpublished paper. Corvallis, OR: Oregon State University.

Attachment E. Jeremy Thomas. 1984. The conservation of butterflies in temperate countries: Past efforts and lessons for the future. In: RI Van Wright and RR Ackery, Eds. The Biology of Butterflies Orlando, FL: Academic Press. pp. 333-353.

Attachment F. Mary O'Brien. 1986. But what about the other half? The fascinating tale of (non-)inerts. Journal of Pesticide Reform. 6(2):6-7.

Attachment G Brief for the Appellants before the Ninth Circuit Court of Appeals. November, 1985. Oregon Environmental Council, et al. v. Leonard Kunzman, et al. Civil case nos. 85-3972, 85-3984.

Attachment H Statement of Selina Bendix to the Oregon District Court. March, 1985. Oregon Environmental Council, et al. v. Leonard Kunzman, et al. Civil case #82-504-RE

Attachment I Mary O'Brien. June 29, 1986. Carbaryl Fact Sheet. Eugene, OR: Northwest Coalition for Alternatives to Pesticides.

DEC 2 3 1988

Willapa Hills Audubon Society

P. O. Box 93 – Longview, WA 98632

000096

12-19-88

Dear Mr. Torrence,

We are interested in the Spruce Budworm Project and are glad to see that you're in favor of using B.t. This past season's successful projects are enough to test its' worthiness. I (We) hope you will select Alt. "B" and not "D", which includes the use of carbaryl. B.t. not only does well the year it's sprayed, but it doesn't harm the preditors so they will be around in following years to help clean up the Budworm population left. Carbaryl kills indiscriminately and could cause great harm to aquatic life.

Sincerely,

Mary Nelson

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 SIXTH AVENUE
SEATTLE, WASHINGTON 98101

DEC 2 2 1988

000097

REPLY TO ATTN OF: WD-136

RECEIVED

DEC 27 1988

James F. Torrence
Regional Forester
Pacific Northwest Region
P.O. Box 3623
Portland, Oregon 97208

Dear Mr. Torrence:

In accordance with our responsibilities under the National Environmental Policy Act and Section 309 of the Clean Air Act, we have reviewed the Draft Environmental Impact Statement (DEIS) for the Management of Western Spruce Budworm in Oregon and Washington. The current western spruce budworm outbreak began in 1980 and encompasses about 7 million acres. This EIS evaluates what should be the strategy for managing the current outbreak. The DEIS identifies two preferred alternatives, Alternative B (spraying of Bacillus thuringiensis (B.t.), a biological insecticide) and Alternative D (spraying of B.t. and Carbaryl, a chemical insecticide).

Based on our review we have rated the DEIS LO (Lack of Objections). Our review has not identified any potential environmental impacts that would require any changes to the preferred alternatives. The following comments, however, should be addressed for clarification.

An evaluation and discussion of the potential for ground-water contamination from spraying is needed. Carbaryl is among the list of priority pesticides listed by EPA as having a high potential for leaching into ground water. The FEIS should examine the potential areas to be sprayed that are recharge zones for private and public ground-water supplies.

One of the listed mitigation measures for water quality for aerial insecticide application is a buffer zone of "at least one swath" adjacent to streams. What is the typical width of this swath? Will this swath be wide enough to avoid most riparian zones? Will intermittent streams be included in this mitigation measure?

The summary on page 5 mentions the role of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This should be expanded to make it clear that any application of pesticides will conform to the application rates allowed and restrictions on the label.

The discussion of cancer risk on page III-17 is misleading, particularly in regard to the risk from eating pesticide-treated foods. The National Research Council's (NRC) study estimated the theoretical risk from cancer. Besides extrapolating from high dose animal studies to the low levels expected in human

diets, the NRC assumed that all crops would be treated and would carry tolerance-level pesticides. These are conservative assumptions.

Thank you for the opportunity to review this DEIS. Please contact Wayne Elson at (FTS) 399-1463 for any questions concerning our comments.

Sincerely,

Ronald A. Lee

Ronald A. Lee, Chief
Environmental Evaluation Branch

WFPA

WASHINGTON FOREST PROTECTION ASSOCIATION • 711 CAPITOL WAY, EVERGREEN PLAZA BLDG., SUITE 608 • OLYMPIA, WA 98501 • (206) 352-1500

December 22, 1988

RECEIVED

DEC 27 1988

Mr. James F. Torrence
Regional Forester
USDA Forest Service, Region 6
P.O. Box 3623
Portland, OR 97208

Dear Mr. Torrence

The Western Spruce Budworm is one of those forest pests we'd like to see go away but it has not and most likely will not. The Forest Service has recognized this in its draft environmental impact statement dealing with the Spruce Budworm.

The document itself appears complete with the extent of your decisions and their potential impacts sufficiently addressed. With the spring season only a few months away, it is time to move forward to move the decision making process into he field. Alternative D appears to be the most preferable alternative. Alternative D provides the flexibility of site specific adaptability to deal with technical, social and political problems presented by the need for Spruce Budworm control.

Parenthetically we note the document mentions the carbaryl application rate to be 0.5 pounds of active ingredient per acre. It is our understanding the label requires 1.0 pounds per acre active ingredient. We assume this to be a typographical error but it should be corrected.

WFPA appreciates the opportunity to comment on the Forest Service efforts to get on with Western Spruce Budworm treatment. We wish you well. If you have any questions, please feel free to call our office.

Regards,

M. R. Dick

Malcolm R. Dick, Jr.
Director of Forest Management

MRD:sh

cc: WFPA Forest Management Committee

Timothy Coleman
POB 361
Republic, Wa. 9911

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000000

Pacific NW Region
USDA Forest Service
319 SW Pine, POB 3623
Portland, Oregon 97208

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DEC 27 1988

RE: DEIS Management Western Spruce Budworm in Oregon and Washington

I feel that many present abnormalities occurring on the Forest ie; insect damage, wildfire, landslides, riparian damage, etc., have been caused by "modern" Forest prescriptions. Silviculture prescriptions calling for Clear-cutting & replanting of single specie trees {monoculture} are the root cause of the majority of these perversions.

In the case of the Spruce Budworm management proposals you have once again ignored your past history. Instead of changing your silvicultural practices - you propose to change the natural processes. The Spruce budworm & Pine bark beetle are native insect species. The reasons for their recent increases in population are the direct result of fire suppression and monoculture forest practices.

Planning Questions

#1 The economic implications should receive a backseat to environmental considerations. For to long has this Planet been viewed ~~dug~~ ~~placed~~ in terms of it's ability to be mined, harvested, bought and sold. The focus must be changed to bring us back into

a stewardship role.

#2. Because of its effectiveness in erradicating spruce budworm, and because resurgence is ~~a~~ less likely to occur - Bt is the only pesticide which should be used. Bt will not harm beneficial parasites - which provide added protection against Resurgence & Reinvasion. Bt will not harm aquatic insects.

#3 The no action alternative would have no effect on wildlife - but continued poor silvicultural practices will!

Alt-B is best because it protects most all species - is considered effective - and because resurgance, reinvasion, and resistance are unlikely to occur.

Alt-C Carbaryl is a poison to more than the identified insects - its use is unnecessary - and is a waste of time to consider its use.

Alt-D - Bt is exceptable - Carbaryl is not - riparian zones cannot be protected by providing a one swath buffer zone - wind & water migrate-flow to the riparian area and therefore, carbaryl use would be unwise in areas closer than 1/2 mile from class 4 or above streams. Carbaryl should not be used period!

I support Alt-B & A and will do all I can to stop any use of Carbaryl.

Earth First!

Love,

[signature]

000100

OREGON ENVIRONMENTAL COUNCIL

2637 S.W. Water Avenue • Portland, Oregon 97201 • 222-1963

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DEC 27 1988

December 22, 1988

James F. Torrence
Regional Forester
Pacific NW Region, U.S.Forest Service
P.O.Box 3623
Portland, OR 97208

Dear Mr. Torrence,

I'm writing to express various concerns of the Oregon Environmental Council regarding the Draft EIS for management of spruce budworm in Oregon and Washington.

Considering that actual timber mortality rates are so low - one to four percent - and considering that the spruce budworm population has been declining by nearly 50% each year since 1986, OEC believes that the No Action alternative should be preferred.

To the extent that the spruce budworm outbreak is replacing fire as a natural mechanism for enhancing species diversity, any suppression would only slow that process and result in further outbreaks over time. Forest Service resources would be better used as follows:

1) Development of a supplemental EIS which considers Integrated Pest Management strategies and gives district foresters guidance regarding long-term management issues;

2) Silvicultural management practices which would hasten development of stand diversity; and

3) Research on the spruce budworm.

Alternative C, which would allow the use of carbaryl and other chemical insecticides is unacceptable to OEC and its members throughout Oregon and Washington. Carbaryl is nonselective and would kill a broad range of insects, including predator species which help control the spruce budworm, thus encouraging addition outbreaks.

1968 • *"Twenty Years Protecting Oregon's Future"* • 1988

Carbaryl is acutely toxic and has been shown to cause chronic effects including carcinogenic, teratogenic, and mutagenic effects. Besides being toxic to aquatic life, carbaryl has been shown to persist in soils up to eight months and leach into groundwater.

The Forest Service needs to break out of the reactive mode in which it now finds itself by making a commitment to long-term planning which stresses prevention. OEC believes that the suggestions which we've offered here would work to accomplish that.

Thanking you for this opportunity to offer comments, I remain,

Sincerely yours,

Jean C. Meddaugh

Jean C. Meddaugh
Associate Director

000101

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

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DEC 27 1988

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone fulfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

2. The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These references should be corrected to read 1.0 lb. a.i./acre as Don Bilyeu has indicated it was intended to be. The use of 0.5 pounds would be contrary to the manufacturer's recommendations and the historical findings of spruce budworm control in the West.

3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

Ken Karr
Signature

KEN KARR
Name

6802 Carlotta Rd Yakima, WA

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
975 S.E. Sandy Boulevard, Suite 202, Portland, Oregon 97214 Telephone (503) 238-0667

000102

December 22, 1988

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DEC 27 1988

Mr. James Torrence
Regional Forester
Pacific Northwest Region
319 S.W. Pine
P.O. Box 3623
Portland, OR 97208

Dear Mr. Torrence,

The Columbia River Inter-Tribal Fish Commission (CRITFC) appreciates this opportunity to comment on the Draft Environmental Impact Statement (DEIS) for Managing Western Spruce Budworm in Oregon and Washington. The Commission was formed by the Fish and Wildlife Committees of four tribal governments: the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes and Bands of the Yakima Indian Nation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Nez Perce Tribe. These four tribes have rights reserved by treaty; these rights include the right to take fish that pass their usual and accustomed fishing places. Among these fish are the anadromous species that spawn and rear in streams draining 15 of the 19 National Forests in the Pacific Northwest Region. Region 6 contributes anadromous fish to the Columbia River system from the Wallowa-Whitman, Umatilla, Malheur, Ochoco, Wenatchee, Mt. Hood, and Gifford Pinchot National Forests.

Over the past several years, CRITFC has provided extensive comments to Region 6 on the proposed forest plans and DEISs for the National Forests within the Columbia Basin. In addition to substantive comments on the proposed plans and the evaluation of the environmental effects of the plans, these comments described the tribes' treaty rights to anadromous fish and adequate fish habitat, the Forest Service's duty to protect and enhance fish habitat, and the Forest Service's duty to coordinate its land management activities with the goals of Columbia Basin fish managers. See e.g., CRITFC Comments on the Wallowa-Whitman National Forest Proposed Plan and DEIS (July 14, 1986); CRITFC Comments on the Malheur National Forest Proposed Plan and DEIS (December 14, 1987); and CRITFC Comments on the Umatilla National Forest Proposed Plan and DEIS (March 28, 1988).

Indeed, the Forest Service has recognized the need to coordinate its management activities with other federal agencies, states, tribal governments, and the public. According to the Forest Service's Rise to the Future, a primary responsibility of the Forest Service is "ensuring that fish habitats and their associated riparian areas are properly protected." Fisheries Task Force Report, Fisheries Habitat Management USDA-Forest Service March 16, 1987 at 4. Moreover, "evaluating the potential effects of forest management activities on fish habitat is part of that responsibility." Id. at 3.

The Draft Fisheries Task Force Report for the Pacific Northwest Region identified maintenance of existing riparian and fish habitat and water quality as a regional issue. Draft Fisheries Task Force Report, USDA-Forest Service Pacific Northwest Region June, 1987 at 3. The Task Force Report also identified interagency coordination and management as an issue. Id. According to the Task Force Report, over 37 agencies and Tribal governments have fisheries management responsibilities within the Region. The Task Force recognized that "close coordination of all activities is essential." Id. Given this direction, the Regional Office should provide more specific details as to how the Forest Service will coordinate its budworm management activities with other agencies and tribal governments. After all, the Forest Service will tier the annual spray project EAs to its FEIS, and many site-specific activities will require coordination with the tribes and other agencies. The FEIS should provide the public and Forest Service personnel with the requisite guidance as to how coordination will be achieved at the project level.

Given the regional scope of the spruce budworm problem and the obligation of Region 6 land managers to ensure the fulfillment of the federal, state, and tribal anadromous fish rebuilding programs in the Columbia River basin, Region 6 should take every precaution to avoid large scale ecosystem perturbations, even at sub-critical levels, that have the potential of affecting anadromous fish-bearing streams. Elevated temperature, agricultural run-off, mining, road building and logging with their associated sedimentation and channel modifications have, in many cases, radically affected the integrity of the large-scale aquatic production systems that had produced abundant, high quality smolts in the past. The numerous sources of habitat system alterations result in cumulative effects that are in most cases difficult to measure with precision. However, a review of cumulative effects by Schindler (1988) points out that extensive analysis of species composition of aquatic communities is a sensitive means of detecting the progressive, negative effects in ecologic systems. These early warning signs of environmental damage and the approach to critical thresholds are typically unnoticed in routine or cursory surveys of streams. It is for these kinds of reasons that we

view massive spray programs, such as that covered in the Spruce Budworm EIS, as potentially putting the aquatic resources at even more risk than they presently must bear from insufficiently controlled forest management actions such as riparian zone harvest and salvage with resultant temperature effects downstream.

Our primary source of concern with th e spray program is the inclusion of carbaryl as a permitted chemical in the preferred alternative. While it is some comfort to us that carbaryl has not been used in recent year's spraying in the Malheur, Wallowa-Whitman, Umatilla, and Mt. Hood National Forests, we do not approve the risks to anadromous fish if carbaryl eventually is used. We cannot accede to a preferred plan that condones carbaryl out of a belief that this chemical would never be used.

The DEIS states that "[i]nsect (management) activities have the potential to affect fish habitat characteristics such as water temperature; sediment load; turbidity; water quantity, timing of flows; and the character of stream side vegetation. The quality of fish habitat is dependent upon management practices within watersheds." (Summary, p.12). It also states that "significant increases in annual streamflow could result from the cumulative impacts of a severe budworm defoliation and management activities" (Summary, p.13). The DEIS should describe, in detail, how land managers will ensure that these cumulative effects will not occur. Insect management is important, but not as important as restoring Columbia basin fisheries.

The DEIS declares that "[t]he change in species composition from ponderosa pine to white fir or Douglas-fir is accompanied by increased susceptibility to insects and disease." "[T]he late seral stages of tree species were greatly increased later in the 1950's and 1960's by logging practices which selectively removed the ponderosa pine." If sites that are best suited to ponderosa pine have been driven to white fir and Douglas fir, which are not well suited to the sites and are thus susceptible to insect vectors, it appears that the Forest Service feels committed to a path of perpetual over-correction for past ecological errors in forest management. When the Malheur National Forest states that it will attempt to aggressively harvest the bulk of remaining ponderosa pine and convert these sites to Douglas fir sites so that it can realize future increased wood production from those acres, while at the same time capitalizing on the highly valued pine logs, it seems evident that past <u>and</u> present forest management practices will ensure continued insect problems, spray programs, salvage operations, and spruce budworm EISs. A reasoned pest management program should avoid this result.

In cases where ponderosa pine has been selectively harvested, "[r]emoval of the pine overstory has not released the

firs to grow freely. The shade-tolerant understory is overstocked and unthrifty. The poor health of these stands, compounded by the present drought cycle, has resulted in thousands of acres of susceptible host trees" (Summary, p.11). If removal of ponderosa pine does not release Douglas-fir to grow because they are overstocked, does this mean that spray programs are needed? It could as easily be said that overstories of pine should not be removed, Douglas-fir should be thinned in the understories if the acres are part of the commercial base, or the Douglas-fir are not really suited for the site so that ponderosa pine sites should not be converted to Douglas-fir sites. Spray programs appear to be a band-aid for ecologically unsound forest management. The DEIS should delineate those specific situations where the use of specific chemicals, as opposed to some other management approach, is the best way to achieve healthy watersheds. Broad statements permitting the use of B.t. and/or carbaryl at the discretion of the local land manager amounts to issuance of a "spraying license," not implementation of a pest management program.

"Applying carbaryl is not considered likely to prolong the outbreak, and should have only minor effects on natural enemies" (Summary, p.15). However, "[a]quatic insects in the orders Plecoptera (stoneflies) and Ephemeroptera (mayflies) are highly sensitive to low levels of carbaryl. Trichoptera (caddisflies and Diptera (true flies) are also sensitive to carbaryl." "Carbaryl is considered moderately toxic to mammals and slightly toxic to birds." "[C]arbaryl acts as a broad-spectrum pesticide (EPA, 1980)" (Summary, p.16). If carbaryl is as toxic to insects as stated, it is difficult to understand why only minor effects on natural enemies are expected. Are there no predatory insects? Even if predatory insects are not killed outright, it seems likely that effects on the aquatic insects could be substantial. If so, the food base of rearing salmonids could be affected.

"Carbaryl is considered moderately toxic to mammals and slightly toxic to birds" (Summary, p.16). Yet, on the same page it states that "[r]esults of carbaryl studies on birds vary." "One study reported significant declines in bird populations, possibly resulting from reduced food supplies." And furthermore, it is claimed that "[t]he quality of the toxicity data base for carbaryl is adequate" (Summary, p.20). How is a land manager supposed to interpret these statements? Is "moderate" toxicity to mammals always acceptable? In what situations would this level of toxicity require the use of some other pest management method? The DEIS should provide specific citations to data and studies. Then it should delineate how land managers should incorporate and evaluate this information on a site specific basis.

Another inconsistency appears in the evaluation of likelihood of drift. "The results of the risk analysis indicate

there is no significant risk of acute adverse effects to any of the representative aquatic species for typical and worst-case exposures resulting from drift" (Summary, p.17). On the other hand, "[a]erial application of insecticides is very complex because there are so many variables that are uncontrollable. Differences in elevation, slope, and aspect result in varying times of insect and foliage development over an area" (Summary, p.15). With this kind of complexity, spraying throughout extended time periods would be needed for the spray to be effective. This could easily result in spraying the same areas multiple times. Drift is no more controllable in steep terrain than are the patterns of hatching of the budworms yet stream density is far greater on steep lands than on flat ground.

With the preferred alternative "[s]election of either B.t. or carbaryl would allow managers to use the one in a particular situation which best meets the needs of a particular situation. When there is no practical difference, or no concern about potential effects, the choice may be made on economic or other reasons" (Summary, p.15). This statement is cause for great concern. A preferred alternative is selected in an EIS that allows anything from 100% B.t. spraying to 100% carbaryl, depending on the situation. If these alternate agents had similar and negligible ecologic impacts but the efficacy of each depended on existing circumstances, there would be little to worry about. When prepared, environmental assessments (EAs) could discuss present circumstances, possibly weather or stage of larval development, and select the appropriate agent. But when these major ecological choices are left for each EA to treat separately, what prevents District Rangers from claiming a given preferred alternative will have no significant impact because the regional EIS stated that use of either B.t. or carbaryl is acceptable. Spraying budworm infested trees with carbaryl is a far different alternative than spraying with B.t. It is at best misleading to allow this spectrum of options to masquerade under the title of <u>the</u> preferred alternative.

"Carbaryl degrades rapidly in water in 1 to 5 days" (Summary, p.17). Does carbaryl bind to soil particles? If not, it is conceivable that rain after spraying could move carbaryl into streams through the soil in much less than 5 days. In addition, if the "buffer strip must be at least one swath wide" (Summary, p.17) and a swath is only 60 feet (OAR 629-24-203), spraying carbaryl in steep, highly dissected terrain could easily result in drift and soil throughflow to streams if not outright direct deposition on small undetected first-order streams. What stream classification would be used when determining acceptable drainage channels that could be sprayed?

Just because the state of Oregon decided that sixty foot buffers would be the minimum requirement does not mean that these buffers will be adequate in all situations. The Forest Service

is a strong proponent of the idea that one rule cannot possibly be true in all situations. The Forest Service must develop, on an independent basis, the technical rationale behind its recommendations for buffer strips. Buffer strips should be determined on the basis of water quality standards and impacts on beneficial uses.

The Commission appreciates this opportunity to provide comments and looks forward to working with the Forest Service to refine its draft recommendations.

Sincerely,

S. Timothy Wapato

S. Timothy Wapato
Executive Director

December 22, 1988

000103

Mr. James F. Torrence
U.S. Forest Service
319 S.W. Pine
P.O. Box 3623
Portland, Oregon 97208

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DEC 27 1988

Dear Mr. Torrence:

Please accept the following as my personal comments on the Draft Environmental Impact Statement for the Management of Western Spruce Budworm in Oregon and Washington.

As a professional forester, I recommend Alternative "D" for your selection as the USFS Preferred Alternative. This alternative includes all of the necessary details for site-specific silvicultural prescriptions. While it does not require the use of carbaryl on non-sensitive areas, it does allow the opportunity to use it where it is deemed appropriate. Limiting your silvicultural prescription to a single action alternative (B.t. only) would be poor management for some sites. Alternative "B" is fully contained in Alternative "D", and therefore becomes moot as a second preferred alternative. Thus, selection of Alternative "D" is the best short-term and long-term silvicultural and environmental approach to controlling damage by Western Spruce Budworm.

I have been informed that the intended application rate for carbaryl is to be 1.0 pound a.i./acre. I agree with this rate of application, and request the USFS correct the references to 0.5 pound a.i./acre that is mentioned several times throughout the document. The manufacturers do not recommend less than 1.0 pound a.i./acre for control of Western Spruce Budworm.

I found the DEIS document to be poorly organized and terribly disjointed. Although most of the necessary information seems to be contained in the document, it is very difficult to follow. Many titles and subtitles are also missing.

Several areas of discussion seem to be deficient.

(1) Site-specific Environmental Effects (page IV-1) - I agree that project-specific environmental analysis should be required prior to project implementation. The environmental analysis should be of limited scope, however, and should limit itself to how to implement the decisions of this EIS, rather than reviewing every available alternative and long-term control proposal again.

(2) Water Quality/Quantity (page IV-2) - This seems to be deficient in addressing the impacts on water quality. Although the discussion may be fragmented throughout the

document, it should be pulled together into a cohesive and comprehensive discussion under this heading. I expect the impacts to be minimal or none, but this should be addressed in the documentation, as well as the reason behind this finding.

(3) Timber (Managed Stands) (page IV-5) - This section fails to evaluate the potential for losses due to secondary insects and disease. Evidence in Northeast Oregon indicates that losses from these secondary sources may be substantial. It also seems to underestimate the amount of top-kill and the impacts of a reduction in diameter growth. These losses will cause a direct reduction in productivity, and thus the annual allowable cut of the forest. Elsewhere in the DEIS the concept of salvaging the budworm mortality was mentioned. While this is a good idea, the USFS has not thoroughly thought out the impacts of such measures. To salvage the mortality would require covering the entire forest every two or three years! This would create a drastic change in timber quality, volume per acre and logging costs, which would have spinoff impacts on community stability and overall forest conditions.

(4) Insect Complex (page IV-9+) - The documentation on tolerance to insecticides is inconclusive. Thus, USFS summaries should reflect this. In addition, it is not the intention of a control project to use a sublethal dose.

(5) Wildlife (page IV-11+) - This particular section is especially disjointed and must be rewritten into a cohesive, comprehensive presentation. I object to the USFS (apparent) summaries of carbaryl's negative impact and cumulative impact on wildlife and T. and E. species. The studies seem to state overwhelmingly that no negative impact should be expected from spruce budworm control with carbaryl. Those studies that do predict a negative impact (particularly those on avian species) seem to base the prediction on speculation or extrapolation of data beyond what it was intended for, or statistically capable of justifying. I feel the USFS decisions here should be based upon fact, and the decision process must be more fully explained in the documentation.

(6) Fisheries/Aquatic Ecosystem (page IV-19+) - This section also is particularly disjointed and difficult to follow the USFS decision logic. Although the impacts on aquatic insects of carbaryl in streams does appear to be significant, the risk of getting carbaryl into streams should be minimal due to drift control measures required by law. Even if carbaryl enters the streams, the available studies fail to show any deleterious impacts on the fish or other aquatic resources.

(7) Irreversible or Irretrievable Effects (page IV-39) - I feel the net loss of 933 board feet per acre is significantly low, and the cumulative impact of this loss has not been adequately documented.

(8) The full range of alternatives available for spruce budworm control was briefly mentioned, but not really considered. The range considered should have included a more toxic, more effective method of control. By deleting the more toxic alternatives outside of the EIS documentation, the public is mislead to believe that the carbaryl alternative is actually the extreme worst alternative available.

I expect you have initiated some consultation process with the USF&WS regarding T. & E. species and other wildlife impacts. This ongoing consultation is not well documented. It should be better documented, and any written correspondence or confirmation of "no impact" should be included in an appendix in the Final EIS.

In summary, I feel the DEIS likely contains the information necessary to meet NEPA and NFMA requirements, but must be laid out in a more organized, systematic manner in the Final EIS. I see no need for a Supplement to this DEIS. The scope of your decision and its impacts are sufficiently addressed.

I have reviewed the response provided by Gary Weiher for Boise Cascade Corporation, and Bob Messinger for the Northeast Oregon Region of Boise Cascade Corporation. I concur with their comments and include those documents herein by reference.

Thank you for the opportunity to provide these comments. I remain extremely interested in the proper control of damage from Western Spruce Budworm.

Sincerely,

Richard L. Brathovde

Richard L. Brathovde
P.O. Box 51
Yakima WA. 98907

Oregonians for Food and Shelter

567 Union Street, N.E.
Salem, OR 97301
370-8092

"For balance in facts about pesticides"

RECEIVED 000104

December 22, 1988 DEC 27 1988

Mr. Roger M. Ogden
Western Spruce Budworm Project Leader
USDA Forest Service
Pacific Northwest Region
319 SW Pine, P.O. Box 3623
Portland, Oregon 97208

RE: WESTERN SPRUCE BUDWORM MANAGEMENT DRAFT ENVIRONMENTAL IMPACT STATEMENT

Dear Mr. Ogden:

Oregonians for Food and Shelter thanks you for the opportunity to comment on the DEIS for the proposed Western Spruce Budworm Management program in Region 6.

As your summary states, managing the current outbreak effecting 19 National Forests is a major effort. In our opinion it is also an essential effort, and one which should have received greater attention and resources in the past.

At this point in time, the need for a control/eradication program is evident by measurable damage that has, and continues to occur on both public and private lands. Obstructionists who branded the projections made years ago as purely "speculative" were obviously wrong.

A control program should be supported by all sides, since the spruce budworm does not differentiate between old growth and reforested stands; nor between the roadless, wilderness areas and managed forest tracts. The bottom line is we are loosing both types of trees unnecessarily.

The following are comments on several of the proposed alternatives, A through D, and recommendations for developing a better preferred alternative.

1) It is totally unacceptable to consider adopting Alternative A (no action). The Forest Service would be negligent in carrying out its charge to manage the forest lands for any of its multiple-use purposes in a responsible manner. Therefore, "no action"

is not an option which legally can be chosen.

2) A preferred alternative should be developed which is based upon the effectiveness of the control methods or agents to suppress, or preferably eradicate, the target pest without undue risk to the public's health or unacceptable damage to the environment.

Two additional factors need to be considered. The total cost of control per acre, and factors which may reduce the effectiveness of the preferred control method. This can be stated another way, what options can be developed which increase the probability of achieving acceptable control (spruce budworm kill rate) under any given outbreak condition?

3) The DEIS summary reviews the cancer risk to the public and to workers from carbaryl exposures. It concludes that workers are not at risk greater than 1 in 1 million and that risk to the public is about twelve times less than that. Based on current EPA positions relative to "deminimus risk, these are clearly acceptable. Furthermore, the summary states, " No individual member of the public is likely to receive repeated exposures to <u>any</u> of the insecticides..." This would infer that a program incorporating more than one application still presents an acceptable risk.

4) Alternative B utilizes only the biological insecticide B.t. While this has proved to be successful in many applications, the window of effectiveness can be very narrow. If weather or other complicating factors create problems which delay application, efficiency can be greatly diminished or even rendered totally ineffective for the remainder of the budworm's life cycle.

One application period per year does not always lend itself to controlling outbreaks and infestations. The potential for control cannot be that limited. OFS supports the use of B.t. as one of the primary chemicals for control. We do not support it is the only agent.

5) Alternative C only discusses the use of carbaryl although malathion, acephate and mexacarbate are insecticides also currently registered by the U.S. EPA for suppression of western spruce budworm by aerial application.

The summary states the reason for this as, "at this time, carbaryl is the most acceptable chemical insecticide in terms of efficacy..." This again supports the position that the other chemicals do not pose an unreasonable risk. As such, OFS takes the position that all registered chemicals should be available for use, <u>unless</u> scientifically supported evidence can be produced which shows why the product(s) should not be used. Cost effectiveness should be used to determine the recommended order of choice or priority. It should not be used as a means of determining whether a chemical is included or totally elimina

from the program.

6) A preferred plan would be to modify Alternative D to include the use of B.t. in conjunction with any or all registered insecticides, including but not limited to carbaryl. Once it has been determined which of the products (with mitigation measures) do not pose an unreasonable risk, the various insecticide products should then be prioritized according to potential impacts on the environment, efficacy and cost.

The various formulations of B.t. must also be evaluated, particularly as to effectiveness and cost. Past Forest Service experience has shown that not all B.t. formulations are equally effective in this region.

The most appropriate treatment -- B.t., insecticide(s), or a combination of two or more -- should be determined on a project-specific basis. The number of different treatments and/or the boundaries of each would be dependent upon the particular attributes of the area and those factor of concern within that area.

7) The Forest Service should undertake scientific and controlled tests under actual conditions (i.e. test plots) to determine the most effective combination of control products to use. Particular attention should be given to study the effect of combining two or more insecticides as a means of retarding the development of resistance by the budworm. This method has be proven effective in other insect control areas, such as mites.

8) A mechanism also must be established to review and incorporate newly approved products by the U.S. EPA and/or new technologies into the program as they are developed.

The Western Spruce Budworm management program must consider all available tools equally, provided they meet acceptable human health and environmental risk criteria. Those criteria or standards must be established and applied uniformly to all methods of control whether they be cultural, mechanical, biological, or chemical. The ultimate determination, however, should be made based on the risks and benefits of conducting the proposed program versus the risks and loss of benefits from not doing so.

Respectfully,

Terry L. Witt

Terry L. Witt
Executive Director

NORTHWEST
FORESTRY
ASSOCIATION

000105

December 22, 1988

Mr. Roger Ogden
U.S. Forest Service
319 S.W. Pine
P. O. Box 3623
Portland, OR 97208

RECEIVED
DEC 27 1988

Dear Mr. Ogden:

Please accept this letter as the Northwest Forestry Association's comments on the DEIS for Managing the Western Spruce Budworm in Oregon and Washington. The Northwest Forestry Association is an organization of wood products manufacturing companies which operate manufacturing facilities throughout Oregon and Washington. Many of our members are heavily dependent on timber from the national forests and have a keen interest in maintaining healthy, productive forests. Our industry's future will depend to a large extent on the management of the national forests.

The spread of the budworm infestation and the area defoliated has grown at an unprecedented rate in recent years. An active program to aggressively control the problem is unquestionably needed. After control is accomplished, silvicultural practices should be intensified to improve stand quality and capture volume and value before it is lost.

The DEIS identifies two preferred alternatives. This tends to frustrate the public in understanding exactly what course of action the Forest Service is proposing. Only four alternatives are proposed. We agree with your assessment of other alternatives considered but eliminated from detailed study, (sterile males, pheromones, and other chemicals). However, by eliminating consideration of other EPA registered chemicals other than carbaryl in your document, you present the "middle of the road" carbaryl to be an extreme alternative in terms of chemical use.

NFA supports the selection of alternative D, which proposes the use of B.T. and the insecticide carbaryl. The Forest Service appears to have done a good job of evaluating control methods and environmental risks. The indicated risks to other wildlife and aquatic species of the mix indicated with alternative D makes it an excellent tool for use in riparian and other sensitive areas. The combined use of B.T. and carbaryl provides an opportunity to treat the entire infestation area and remain within acceptable EPA risk levels.

1500 S.W. First Avenue, Suite 770 • Portland, Oregon 97201 • (503) 222-9505 • FAX: (503) 222-3255

The stated USDA goal "...to assure an adequate supply of high quality food and wood fiber and a quality environment for the American people," dictates active management of our National Forests. Maintaining healthy forests is critical to our long term interests. There are several critical areas in the DEIS where additional work is needed. We would like to emphasize the need to closely review the excellent suggestions made by Mr. Gary Weiher of Boise Cascade Corporation in his comments to you.

Thank you for the opportunity to comment on this important document. Please keep us informed of future developments.

Sincerely,

R. T. Bailey

Richard T. Bailey
Director of Forest Policy

cc: Bob Messinger
Gary Weiher
Wayne Ludeman
Dave Mumper

20 Dec. 1988
RECEIVED
DEC 27 1988

000106

USDA Forest Service
319 S.W. Pine St.
P.O. Box 3623
Portland, OR 97208

Comments for DEIS "Management of Western Spruce Budworm in Oregon and Washington"

This letter is in support of Alternative B and is opposed to the use of carbaryl.

Inclusion "A" pp. 9-10 discusses control of spruce budworm by carpenter ants. The DEIS Summary p. 16 states "Many insects in the order Hymenoptera...seem to be especially susceptable to carbaryl..." Ants are in the order Hymenoptera. The use of carbaryl would be counter-productive and contradicts the DEIS Summary p. 15 conclusion that "Applying carbaryl...should have only minor effects on natural enemies."

DEIS Summary p. 10 states "Carbaryl poses a human health risk only in the case of accidents." The five year ban on carbaryl use in the Carson National Forest (Inclusion "B") brought up more serious questions of health risks. Inclusions "C" "D" "E" "F" and "G" attest to carbaryl's health risks, especially its teratogenic risks which were not even mentioned in "Carbaryl's Risk Assessment Results" DEIS Summary pp. 19-20.

My own family and many neighbors live adjacent to the Tonasket Unit of the Okanogan National Forest and our own lands were badly damaged by spruce budworm in 1988. While we are therfore very concerned about spruce budworm, we do not want carbaryl in our air or watersheds. The DEIS "one swath" buffer strip is insufficient, usually uncontrollable due to wind drift; and historically the Forest Service has a poor record of monitoring contractors.

Ernie Soya

Ernie Soya, Chairman
Wauconda Stewarship Committee
44 Nota Rd.
Wauconda, WA 98859
(509) 486-1514

Seven inclusions "A" through "G"

Deiro Input
12-30-88
AS

000107

December 16, 1988

Mr. James F. Torrence
Regional Forester, PNW Region
USDA, FOREST SERVICE
Post Office Box 3623
Portland, Oregon 97208

RECEIVED
DEC 29 1988

Dear Mr. Torrence:

Below are my substantive comments to the DEIS for Managing Western Spruce Budworm in Oregon and Washington:

1. Alternative "D" is the best "preferred" alternative. It alone provides the flexibility and site specific adaptability that is necessary for the proper practice of silviculture. It alone permits the choice between the best of the silviculturally, environmentally and ecologically approved tools for spruce budworm management. It alone fulfulls the "...USDA goal to assure an adequate supply of high quality food and fiber and a quality environment for the American people" (DEIS, p. I-10).

2. The DEIS erroneously mentions the carbaryl application rate to be 0.5 lb. a.i./acre in several places. These references should be corrected to read 1.0 lb. a.i./acre as Don Bilyeu has indicated it was intended to be. The use of 0.5 pounds would be contrary to the manufacturer's recommendations and the historical findings of spruce budworm control in the West.

3. I find the document to be adequate in meeting the requirements of NEPA and NFMA. Your analysis and dismissal of the other chemicals and other means of control seems more than adequate. The scope of your decision and its impacts are sufficiently addressed.

4. I recommend you move forward. You will never have perfect data. Do not allow the "paralysis of analysis" to make your decision for you.

Although the DEIS presents a one-sided view of the effects of carbaryl and underestimates the impacts of the "no action" alternative, I feel it is more than adequate in addressing the issues involved in this decision.

Thank you for the opportunity to comment.

Sincerely,

Clark T Rogerson forester
Signature

CLARK T. ROGERSON
Name

20 ECHO Court; YAKIMA, WA 98908
Address

CITY OF

PORTLAND, OREGON

BUREAU OF WATER WORKS

Bob Koch, Commissioner
Edward Tenny, Administrator
1120 S.W. 5th Avenue
Portland, Oregon 97204-1926

December 30, 1988

WA 5

RECEIVED

JAN 04 1988

000108

Roger Ogden
Western Spruce Budworm Project Leader
USDA Forest Service
319 SW Pine, P.O. Box 3623
Portland OR 97208

Dear Mr. Ogden:

Thank you for transmitting the Spruce Budworm DEIS Summary for our overview. The document seems to have adequately addressed the direct impacts of B.T. applications to public water supplies.

Because the mitigation measures weren't specifically listed in the Summary, it is not possible to determine what measures will be taken to minimize risk to public health when B.T. is applied in municipal watersheds. Some I would like to suggest include:

1. Eliminating the use of petroleum products as a carrier, use water only.

2. Utilize portable sanitation, and oil absorbent pads under vehicles and strict gasoline spill prevention procedures at staging areas. Better yet - establish staging areas outside of municipal watersheds.

Thank you for the opportunity to review this document.

Sincerely,

Bruce M. Niss, Deputy Director
Water Quality and Environmental Policy Division

BMN:djs WQX:8812W383

RECEIVED
JAN 11 1988

Box 892
Waldport OR 97394
Dec 31, 1987

Tom L. Thompson
Forest Supervisor
Siuslaw Nat'l Forest
POB 1148
Corvallis OR 97339

Dear Sir.

I have read the DEIS Summary. There has been a lot of work and research done in this area, and I appreciate it.

While I am very opposed to spray, it seems that in this case there is no alternative. Where it will not damage soils, and where streamsides will be spared, B.T. seems to be as safe and sane a control measure as is available. Spray away.

Your friend,
Lola Landis

B: Consultation

APPENDIX B

Consultation

Public Involvement Process

There has been public involvement throughout development of this EIS.

The public's interest in the management of the western spruce budworm situation in Oregon and Washington continues at a high level. The Interdisciplinary (ID) Team which conducted this EIS used the public involvement process developed in 1986, 1987, and expanded upon in 1988, as the basis for this EIS.

In 1986, an extensive public involvement process was initiated which included gathering background information from documents of other agencies pertaining to budworm management, newspaper clippings, and appeals from past decisions; as well as issues and concerns gathered over the previous years.

Several meetings were held with interested or concerned parties in both Oregon and Washington in 1985, 1986, and 1987 for additional input. In the fall of 1987, there were several news releases regarding analysis of the western spruce budworm situation.

In October 1987, a letter was sent to cooperators and all interested individuals on the mailing list, requesting additional input and indentification of any new issues and concerns. Based on these responses, it was determined that the major issues and concerns described in the 1986 and 1987 Environmental Analyses were still valid.

Informal consultation with the United States Department of the Interior, Fish and Wildlife Service, has been initiated through telephone contact and written request regarding the status and mitigation measures for threatened and endangered species occurring within the current outbreak area. The U.S. Fish and Wildlife Service provided lists of threatened or endangered species. With the concurrence of the U.S. Fish and Wildlife Service, mitigating measures were developed to ensure no effect on threatened, endangered, or candidate plant and wildlife species.

A mailing to help identify issues, concerns, and opportunities, and requesting comments and concerns on the current western spruce budworm infestation was distributed to approximately 2,000 addresses in May 1988. Press releases were mailed to the media in the affected areas requesting comments and concerns on the proposed Environmental Impact Statement for management of the western spruce budworm in Oregon and Washington.

A total of 206 responses was received through distribution of the scoping brochure and included approximately 550 substantive comments. These comments, along with comments, concerns, and opportunities from prior public input, were analyzed to identify issues, alternatives, and analysis criteria needed to evaluate the possible alternatives.

Major Issues And Concerns

Beginning in 1981, and continuing through successive years of environmental assessments (EAs), numerous concerns have been expressed about the current western spruce budworm outbreak, and associated spray programs, in the Pacific Northwest. The issues and concerns developed during the 1984 northeastern Oregon analysis were used as a starting point to build upon during 1985. The public involvement steps used for scoping in 1986 included meetings and written inquiries. In 1986, 1987, and 1988, additional public meetings were held by individual Forests. In addition, interested parties were solicited in writing for additional issues and concerns that were not addressed in prior EAs. Public meetings, personal consultations, news clippings, and correspondence resulted in identification of public issues and management concerns. These items reflected the views of concerned individuals, forest-based industries, landowners of various-sized forest holdings, forest resources user groups, conservation and environmental groups, Indian tribes, and representatives of local, State, and Federal agencies and governments.

Use of Public Input in the Process

The public's response to the above steps contained a broad array of opinions about issues, concerns, opportunities, and alternative actions. Using this

information, the ID Team identified the eight major issues elaborated in Chapter I, and developed the alternatives and mitigation measures described in Chapter II of this EIS.

Based upon responses to mailings conducted as part of this EIS, and concerns identified in past EAs, eight major public issues were identified in the scoping process. They include silviculture; water quality and quantity; fish, wildlife, and domestic animals; economics; human health; effectiveness of treatment methods; timeliness of treatments; and fuels and fire.

Individuals and Organizations Consulted

During the course of analyses conducted during the present and past years, the following individuals and organizations were consulted:

USDA FS, Malheur NF, Richard Gritz, Forest Fish Biologist

USDA FS, Malheur NF, Kirk Wolff, Forest Hydrologist

USDA FS, Mt. Hood NF, Dean Longrie, Forest Wildlife Biologist

USDA FS, R8, Dave Smith, Team Leader, Gypsy Moth EIS

USDA FS, RO, Grant Gunderson, Wildlife Biologist

USDA FS, RO, Kathy Johnson, Wildlife Biologist

USDA FS, RO, Gary Larsen, Group Leader VMT

USDA FS, RO, Iral Ragenovich, Group Leader, Entomology

USDA FS, RO, James Hadfield, Group Leader, Pathology

USDA FS, RO, Roger Sandquist, Entomologist

USDA FS, Umatilla NF, Rodney Johnson, Wildlife Biologist

USDA FS, Umatilla NF, Randy Dohrmann, Resource Assistant

USDA FS, Wallowa-Whitman NF, Rod Miller, Forest Wildlife Biologist

USDA FS, Wenatchee NF, Robert Cooper, Research Technician

USDA FS, Wenatchee NF, Norm Anderson, Forestry Technician

USDA FS, Wenatchee NF, Jim Taylor, Resourse Assistant

USDA FS, Wenatchee NF, Susan J.L. Stepniewski, District Wildlife Biologist

USDA FS, Wenatchee NF, Bill Garrigues, District Hydrologist

USDA FS, Wenatchee NF, Steven Kessler, Forest Fisheries Biologist

USDA FS, WO, Larry Gross, Washington, DC

USDI Bureau of Indian Affairs, Terry Luther, Wildlife Biologist

USDI Bureau of Indian Affairs, Richard French, Forester

USDI Bureau of Indian Affairs, Tom Haberstroh, Pendleton, OR

USDI Bureau of Indian Affairs, Glen Lisle, Toppenish, WA

USDI Bureau of Land Management, Stanley D. Butzer, Portland, OR

USDI Fish & Wildlife Service, Ronald W. Hesselman, Clackamas, OR

USDI Fish & Wildlife Service, Dianna Hwang, Wildlife Biologist

USDI Fish & Wildlife Service, Russell Peterson, Field Supervisor, Portland, OR

USDI Fish & Wildlife Service, Jim Michaels, Wildlife Biologist

USDOE, Bonneville Power Administration, Anthony R. Morrell, Portland, OR

OR State Dept. of Fish & Wildlife, Mark Henjum, Regional Nongame Biologist

OR State Dept. of Forestry, LeRoy Kline, Salem, OR

OR State Dept. of Forestry, Dave Overhulser, Salem, OR

OR State Dept. of Forestry, Paul Joseph, I & D Forester

OR State University, College of Forestry, Carl H. Stoltenberg, Corvallis, OR

WA Dept. of Natural Resources, Chuck Chambers, Lead Biometrician

WA Dept. of Natural Resources, Deborah Naslund, Data Mgr. Nat. Heritage

WA Dept. of Natural Resources, Larry Charlton, Ellensburg Local Manager

WA Dept. of Natural Resources, Art Stearns, Olympia, WA

WA Dept. of Natural Resources, Bernard Murphy, Klickitat Dist. Manager

WA State Dept. of Agriculture, Eric LaGasa, Entomologist

WA State Dept. of Fisheries, Dan Blatt, Wildlife Area Manager

WA State Dept. of Game, Phil Peterson, Habitat Manager

WA State University, Wayne Wehling, Pullman, WA

Boise Cascade Corp., Ed Schroeder, Silviculturist

Boise Cascade Corp., Rick Brathovde, Silviculturist

Boise Cascade Corp., Bud Fisk, Area Forester

Boise Cascade Corp., William G. Howard, Chief Forester, Yakima, WA.

City of The Dalles, William R. Keyser, The Dalles, OR

City of The Dalles, John E. Dennee, The Dalles, OR

Cunningham Sheep Co., Lou Levy, Pendleton, OR

Northwest Coalition Against Pesticides, Norma Grier, Eugene, OR

Northwest Forestry Assoc., James C. Geisinger, Portland, OR

Oregon Environmental Council, Jean C. Meddaugh, Portland, OR

Oregonians for Food & Shelter, Terry L. Witt, Salem, OR

Oregonians for Food & Shelter, Paulette L. Pyle, Salem, OR

Our National Forests, Inc., Larry L. Cribbs, LaGrande, OR

Prairie Wood Products, Ronald S. Yockim, Riddle, OR

Washington Friends of Farms/Forests, Duncan C. Wurm, Olympia, WA.

Western Forest Industries Assoc., Ralp Saperstein, Portland, OR

Western Washington Toxics Coalition, Karen Murphy, Seattle, WA.

Willamette Inst. Biol. Contr., Evelyn Lee, Eugene, OR

Paul Buffam, Retired Forest Service, Beaverton, OR

John J. Howard, Union County Courthouse, LaGrande, OR

Joe Pessich, Portland, OR

Sandra Saint-John, Portland, OR

Chet & Mary Schiewe, Pendleton, OR

[illegible]

Coalition Against [illegible]

[illegible]

Howard, [illegible]

[illegible]

C: Standards and Guidelines

APPENDIX C

Standards And Guidelines

Project Implementation Plan

Environmental Assessments which prescribe direction suppression measures will require a written Project Plan before treatment projects may proceed. Logistics of the proposed operations will be described in depth. In addition, the Plan will address how the public is to be notified of spray operations, what specific safety concerns exist or are expected to exist, how project operations will be monitored, and how accidents and spills will be prevented. Contingency plans will be included, to describe procedures would be followed in the event there are accidents or spills.

Public Information Plan

Before any project is implemented, the Incident Commander (IC) will prepare and follow a public information plan. Timely notification will be presented to any individual or group of individuals who may be in or near the project vicinity when spray operations are in progress. Individual members of the public may, by special request, be sent notices of spray dates and times. Range permittees, for example, have requested special notification; because of the need they may have to move livestock before operations begin. The public will be notified about any possible adverse effects that spray may have on automobile finishes. Warning signs will be posted along the perimeter of treatment areas and will be bilingual (English and Spanish).

Pretreatment Reviews

Budworm population levels must be verified through early spring larval sampling before insecticide application is begun. Changing weather conditions may in some instances have caused the collapse of budworm populations.

Before treatment, the IC will review the current status of analysis units that fall within Wildernesses, roadless, or further study areas to ensure that any treatment decisions that may have been made on these areas remain valid.

Prespray Operations

Treatment block boundaries, heliports, and airstrips will be mapped before operations begin. Treatment block perimeters will typically be described by topographical or other physical features whenever possible:

Drainages and streamcourses

Ridges

Roads

Property lines

Slope and aspect

Altitude

Other distinguishing landforms

Sensitive areas

Heliports and airstrips will be located so they are within or near the blocks to be sprayed. They must be large enough to accommodate all necessary equipment and personnel. They must also be accessible to ground transportation, and meet all environmental standards. All USDA Forest Service aircraft safety limits must be met.

Spray Operations And Contract Administration

Experience gained in recent years has demonstrated that certain procedural and administrative cautions must be emphasized when spray operations are conducted, to ensure that safe and satisfactory work is performed. These cautions are described as follows:

Insecticide formulations will be applied under weather conditions recommended by the manufacturer(s). Weather parameters will vary, depending on the particular formulation being used. Wind speed and

direction, turbulence, air temperature, relative humidity, temperature inversion, probability of rain, visibility, and the presence of moisture on foliage which is to be treated; are all factors which will be considered before spraying operations will be possible. Tolerance guidelines for each of these environmental parameters will be included in the insecticide application contract.

Rotary atomizers will be required, as a means of controlling the range of spray droplet size.

Contractors will be required to provide equipment which meet all applicable operational and safety standards. Inspections will be conducted on all equipment before and during operations.

Pilot cars will be used to guide the contractors' insecticide transportation vehicles to helispots.

The IC will ensure all contract administration personnel are fully qualified to perform their assigned duties, and that they are fully aware of their responsibilities and authorities.

Application Team Leaders and other contract administration personnel will exercise "shut-down" authority when they observe aircraft safety violations.

The IC will place special emphasis upon reducing or eliminating the following types of errors:

- Spraying areas that have been designated as no-spray.
- Treating designated areas more than once.
- Spraying areas outside the designated spray blocks.
- Non-uniform coverage of the target area.

Aerial Observation

In order to monitor and control insecticide application, treatment aircraft will be accompanied by an observation aircraft staffed with a fully qualified aerial observer. Observation aircraft are an integral part of ensuring areas are treated with insecticides in an effective manner. Aerial observers monitor swathing, spray behavior, calibration, and keep an accurate record of which areas have been treated and when. They also serve as a safety backup to the spray pilot to help locate aerial hazards, avoid sensitive areas, and provide immediate location of a spray aircraft if it crashes. In past projects, when observation aircraft were not used one-on-one with spray aircraft, the quality of application decreased to unacceptable levels (NOTE: application contractors are paid on gallons of insecticide sprayed, not on acres treated in an acceptable manner; thus, without close supervision, there is a tendency to be more concerned with the number of gallons sprayed rather than the quality of application). With less than one observation aircraft per spray aircraft, time is wasted ferrying between spray blocks, calibration checks are not as reliable, the Contractors' word must be taken for which areas have been treated, and there is less control of protection of sensitive areas.

Each observer will be familiar with the local terrain and have authority to control all activities of the application aircraft. Observers and application pilots will fly each spray block for familiarization prior to spraying.

Spray Deposit Cards

Spray deposit cards are used as a quality check to see if insecticide coverage is adequate, and if the insecticide is reaching the target in an acceptable form. This information, when gathered just after an area has been sprayed, is extremely valuable to the Application Team Leader. This information, along with that of the Aerial Observer, is used to determine if spraying should continue. The information from the spray cards is also valuable in helping the Aerial Observer determine results on-the-ground in relation to conditions observed in the air. A few spray cards placed around each budworm post-treatment evaluation plot will give a qualitative check on coverage obtained. This often gives some insight into post-treatment results.

At least one card line will be placed in each spray block. A few cards will be placed at each budworm evaluation plot. Ground Observers will place cards at their location within the spray block to give immediate feedback on spray deposit after the aircraft has made its run.

Spray Standards

Weather

Moisture, wind, humidity, and air and ground temperatures are important factors affecting spray drift and upward rise of spray droplets.

The maximum allowable wind speed while spraying is 8 miles per hour. No spraying will be attempted, and all spraying will cease, if wind speeds are in excess of 8 mph in the spray block. If the application aircraft pilot is unable to compensate for spray drift caused by wind speeds less than 8 mph, or if wind will cause drift into off-target areas, spraying will stop.

No spraying will occur when fog or low clouds cover the spray area.

Spraying may occur when foliage is damp or wet as long as the foliage is not dripping. This condition will usually exist in the early morning hours.

No spraying will take place when it is raining, or if rain is predicted within 6 hours of spray application. Spraying can occur following rain if the foliage is not dripping.

Conditions may exist that will cause a rapid decrease in humidity in a very short time. When this occurs, and it is detected that spray droplets are not reaching the ground, spraying will cease until the humidity stabilizes.

Spraying will not occur when the air temperature at application altitude is 35 degrees or less, or above 70 degrees Fahrenheit. Application altitude is defined as the altitude of the application aircraft.

If the temperature at application altitude is warmer than the surface temperature (even if less than 70 degrees), the spray will begin to 'hang.' From the side, the spray pattern would have a 'camel back' appearance. Spraying will stop when this condition exists.

If the surface temperature rises faster than the application altitude temperature, an up-draft will occur causing the spray to rise. This can be especially evident on southern exposures and dark terrain features early in the morning. When this condition exists, spraying will cease in the area. This may be a localized phenomenon and spraying could continue in another portion of the block.

An inversion occurs when cool air is trapped at the surface by a layer of warmer air. An inversion is not a problem if the application aircraft can work within the layer of cooler air. If the aircraft cannot work in the lower area, the spray will not penetrate the cooler air mass and will drift off target. Spraying will be suspended when this condition exists. Surface and application altitude temperatures should be monitored to determine when the inversion breaks down and application can resume.

Mechanical Operations

Application operations will be suspended if any of the following problems with aircraft are present:

- Aircraft mechanical problems
- Malfunctioning spray system including; plugged nozzles, leaking system, nonoperating quick dump (unless load is calculated for non-jettisonable load)
- Communications problems
- Pilot is not in a functional condition

If there is one batch truck present, spraying activities will be suspended if any of these conditions exist:

- No operator available
- Nonfunctioning meters
- Leaky or faulty system
- Nonoperating pump
- Personnel

Spraying will be suspended if the following personnel are not present or are nonfunctional:

- Observation pilot
- Application pilot
- Aerial observer
- Application equipment manager (unless duties are performed by application team leader)
- Contractors' ground crew
- Fuel truck driver

Sensitive Areas and Situations

Avoid flying over organic farms. If farm is in approach or departure path from spray block, ensure that area is not inadvertently treated. Suspend spraying when weather conditions exist that could cause drift into adjacent blocks.

Avoid unnecessary flights over areas identified as containing horses, turkeys, and other exotic or timid animals.

Avoid flying over areas containing large numbers of people outside, such as sporting events, golf courses, schools, etc.

If protesters are in the area, suspend spraying where there is any threat to employees, Contractors' employees, or public safety. Spraying will continue only if there is no safety threat present.

Any areas set aside at the Forest Supervisor's discretion will be avoided or buffered during spray operations.

The Pacific Northwest Forest and Range Experiment Station must be contacted to determine if long-term research projects are located in proposed treatment areas. These projects are to be avoided and buffered if requested.

Accident Contingency Plan

The Project Director will prepare and follow a written contingency plan for dealing with accidents and insecticide spills. The plan will specify other agencies involved, and list authorities and responsibilities. The plan will detail the notification procedures. Provisions

for minimizing potential adverse effects from spilled insecticides will be specified.

Spill Management

The objective of spill management is to eliminate the possibility of spills by planning and monitoring any operations where insecticides, diesel, jet fuel, or other petroleum-based products are being used. In the event of a spill, project personnel will take immediate action to correct the problem. These protective efforts will be continuous and progressive; actions taken will be dependent upon the product and the nature of the spill.

Contractors' Responsibilities

Cleanup and disposal of any leaks or spills will be the responsibility of the Contractor. Cleanup and disposal will be accomplished in accordance with any applicable State laws and regulations. Forest Service and State personnel will assist the Contractor in any containment notification or monitoring effort, but will not assume any of the Contractors' liabilities.

Prior to beginning work, the Contractor will submit to the COR a spill plan which indicates to the Forest Service, the State Department of Environmental Quality (DEQ), and other agencies that the Contractor is aware of the environmental concerns and is implementing as many safety procedures as is deemed necessary. The spill plan should indicate the Contractor has the knowledge and ability to minimize the effects of any accidents that might occur.

The spill plan must be a document that stands on its own. It will be approved, before operations begin, by the State DEQ responsible for the area in which the Contractor will be spraying.

Project Personnel Responsibilities

Contractor spill plans will be reviewed by the Incident Commander, Operations Section Chief, Contract Administrator, and the Safety Officer. Designated project personnel will provide guidance and assistance to the Contractor to meet project objectives.

The Contract Administrator will ensure that the Contractors involved in incident spills, complete control and cleanup actions to the extent necessary to protect the environment and meet standards set by the appropriate Federal and State laws and regulations. Documentation and followup will be done by the Safety Officer.

Incident Procedures

All incident spills will be reported in accordance with the Operation Plan and Project Management Guidelines. The nature of the incident spill will determine how it is handled.

Small leaks or spills will be handled by on-scene personnel. Such leaks or spills will be corrected by the Contractor and recorded in the Contract administrator's log. Such incidents may not hinder the operation progress. This type of incident may include the following: a leaking valve, an equipment malfunction, overfilling a tank, or any problem that can be corrected by simple maintenance.

A minor incident does not cause any significant interruption of the project operation. Minor incidents are those that do not threaten life, health, or property directly and immediately. Minor incidents are not perceived by the public to be a problem. Minor incidents, such as leakage of petroleum products at a heliport or soil contamination from a leaking tank truck, will be corrected through prompt action by project personnel. Minor incidents will be recorded in the Contract Administrator's log, and may require some outside notification.

If a major incident occurs, disruption to the project operation is imminent. Major incidents are emergencies or incidents that cause an immediate threat to life, property, or resources. An overturned tank truck that has dumped insecticide into a stream supplying nearby domestic water is an example of a major incident. Major incidents will require notification of various jurisdictions, and requests for assistance will be as needed.

Spill Control Techniques

The following control techniques may work in many incidents, but the Contractor and incident personnel must be prepared to react to a spill using the most up-to-date procedures available:

Dirt berms may be used to stop the spread of a spill or divert it to less sensitive areas. Petroleum products float on water, providing an opportunity to contain the spill by means of floating barriers such as straw or specifically designed absorbent materials.

Spills can be soaked up with dirt, sawdust, newspaper, or almost anything that will absorb the contaminant. Special absorbent pads or pillows may be necessary. Sweeping compound works well to soak up spills on paved or hard surfaces.

State DEQ or other specialists may suggest methods of control to neutralize a contaminant and prevent damage.

If an incident occurs, thorough investigation and analysis of the cause must be completed to assist in development of future preventative measures. Investigations may include personnel from an outside agency if an incident involves multijurisdictions.

Economic Considerations

The initial economic ranking and selection of areas for treatment is predicated, in part, upon a projection of per-acre treatment cost. This projection is usually based on bid and project cost data from previous years. Changes between past and current market conditions, as well as the size of the suppression effort, can cause differences between projected treatment costs and actual contract bid award costs. Any significant differences between actual and projected costs will necessitate a reevaluation of the economic propriety of treatments.

When significant disparity arises between projected and actual bid-per-acre application costs, the economic information upon which initial treatment decisions were made becomes invalid. This undermines the quality of management decisions to treat various areas. Under such circumstances, it will be necessary to reevaluate the economic priorities of areas using actual bid prices. Some units may no longer meet the initial economic criteria for selection. Under these circumstances, additional consideration may be needed to review unit treatment priority.

Noneconomic And Incommensurable Considerations

Noneconomic considerations and forest outputs that are not amenable to dollar valuation often play a major role in the selection of treatment areas. When the treatment budget is limited, units which yield higher cost-benefit on dollar-valued outputs may be dropped in favor of those displaying significant noneconomic and nondollar values. The result is a loss in dollar benefits, often termed "opportunity cost" or "foregone benefits." When the costs of treatment are similar, a rational decision to drop a unit yielding greater dollar returns implies a judgment on the magnitude of the noneconomic and nondollar gain of the substitution. The implication is that the value of the newly included unit's noneconomic and nondollar benefits exceeds the reduction in dollar-valued benefits of the unit replaced. An example would be the treatment of a visual corridor to the exclusion of a highly productive timber area.

Decisionmakers must be fully apprised of the opportunity costs associated with selecting units for treatment primarily on the basis of noneconomic and nondollar values. Apprisal necessitates the decision process make a clear statement of the foregone dollar benefits or the opportunity cost. In this way, decisionmakers can better judge whether intangible and incommensurable values have a value to society in excess of the known and quantified benefits foregone.

Protection Of Water-related Resources

Aerial insecticide application near streams and open water is controlled by State law. In Oregon, State regulatory agencies have agreed that *B.t.* may be aerially applied parallel to and up to the edges of streams and open water. A variance must be obtained from the State Department of Ecology to apply *B.t* up to the edges of streams in Washington State.

A buffer zone must be left adjacent to streams, lakes, wetlands, and other waterways when applying carbaryl. This buffer strip must be at least one swath wide.

The following measures will be used to minimize the probability of unintentional adverse effects on water-related resources and nontarget organisms from spills or application errors:

- Aircraft spray equipment calibration testing over wetlands or floodplains will be prohibited.
- Transportation of insecticides or fuel on roads within municipal watersheds will be guided by pilot vehicles.
- Helispots will not be located in or adjacent to meadowland or floodplains.
- Wetlands, including lakes and ponds, which are large enough to identify from the air will not be oversprayed with insecticides. There may be relatively small wet areas that, because of the tree canopy cover, cannot be identified from the air which will be unavoidably but inadvertently sprayed.

Protection Of Nontarget Organisms

The Incident Commander of any spraying operation will coordinate with local State and Federal land managers to ensure that appropriate protection measures are implemented to mitigate possible adverse effects to beneficial insects and the nesting habitat of eagles and other raptors. Mitigating measures for threatened or endangered species, developed with the concurrence of the U.S. Fish and Wildlife Service, will be incorporated into the project operations plan to ensure that treatment and related activities will have no effect.

In areas planned for treatment, the IC will coordinate with the Forest Service Area Ecologist to determine what action is appropriate to assure that threatened or endangered plants are protected. Areas important to threatened or endangered species will be avoided if necessary.

Protection Of Cultural Resources

Possible cultural resource sites in previously unsurveyed and undisturbed areas are a concern. The Project Director of treatment projects will ensure that areas such as planned helispots, truck parks, or staging areas are surveyed for cultural resource values by a qualified person before ground-disturbing activities occur. Any cultural resource sites discovered will receive appropriate protection.

Protection Of Wilderness Values

The Forest Service Manual defines several objectives in regard to management of insects and plant disease in Wildernesses (FSM 2324.1):

1. "To allow indigenous insect and plant diseases to play, as nearly as possible, their natural ecological role within wilderness.

2. To protect the scientific value of observing the effect of insects and diseases on ecosystems and identifying genetically resistant plant species.

3. To control insect and plant disease epidemics that threaten adjacent lands or resources."

The following policy will be followed when considering treatment in Wildernesses:

The life cycle of the western spruce budworm suggests that the lack of treatment of Wildernesses does not pose a threat to non-Wilderness (i.e., adjacent) lands, nor threaten the resources within Wildernesses. Therefore, in the majority of instances, natural processes will be allowed to continue without control in Wildernesses.

In situations where the spruce budworm infestation in a Wilderness might affect adjacent non-Wilderness resources, treatment will be evaluated on a case-by-case basis.

Population levels will continue to be monitored "in a manner that preserves the wilderness character of the area."

If control measures become necessary in specific cases to prevent unacceptable damage to lands adjacent to a Wilderness, treatment measures must have the least impact on the Wilderness resource and be compatible with Wilderness management objectives.

Identification Of Visual Treatment Needs

Selection of an area to receive suppression of budworm activity for protection of visual values will be based on a priority system using criteria of sensitivity level, distance zones, and foliage quality objectives. The Landscape Architect on each National Forest will identify the priorities for suppression based upon these criteria.

Distance Zones

Distance zones are divisions of a particular landscape being viewed. They are used to describe the part of a characteristic landscape that is being considered for budworm suppression. The three distance zones are:

Foreground

The limit of this zone is based upon distances at which details can be perceived. Normally, in foreground views the individual boughs of trees form texture. This zone will usually be limited to areas within one-fourth to one-half mile of the observer, but must be determined on a case-by-case basis as should any distance zoning.

Middleground

This zone extends from the foreground zone to 3 to 5 miles from the observer. Texture normally is characterized by masses of trees in stands of uniform tree cover. Individual tree forms are usually discernible only in very open or sparse stands.

Background

This zone extends from middleground to infinity. Texture in stands of uniform tree cover is generally very weak or nonexistent. In very open or sparse timber stands, texture is seen as groups or patterns of trees.

Sensitivity Levels

Sensitivity levels are a measure of people's concern for the scenic quality of the National Forests.

Sensitivity levels are determined for land areas viewed by those who are traveling through the Forest on developed roads and trails, using areas such as campgrounds and visitor centers, or are recreating at lakes, streams, and other water bodies.

Three sensitivity levels are employed, each identifying a different level of user concern for the visual environment:

Level 1 - Highest Sensitivity

Level 2 - Average Sensitivity

Level 3 - Lowest Sensitivity

Level 1

Sensitivity Level 1 includes all seen areas from primary travel routes, use areas, and water bodies, where as a minimum, at least one-fourth of the Forest visitors have a major concern for the scenic qualities. Examples are all areas seen from:

- Primary roads, primary trails used by hikers and horsemen, and primary use sites within National Parks, National Recreation Areas, Wildernesses, and other dedicated Wild Areas.
- All public transportation systems of national importance including railways.
- Primary areas of fishing, swimming, boating, and other active or passive recreation on or adjacent to water bodies such as streams, lakes, ocean, etc.
- Primary recreation areas (vista points, campgrounds, picnic grounds, beaches, visitor centers, trail camps, etc.)
- Primary resorts and winter sports areas.
- Primary geological areas.
- Primary botanical areas.
- Primary historical sites.
- Areas of primary importance for observation of wildlife.
- Primary summer home tracts.
- Highly sensitive communities where a large portion of the population is not directly related to performing Forest land management activities.

Sensitivity Level 1 also includes all seen areas from secondary travel routes, use areas, and water bodies where at least three-fourths of the Forest visitors have a major concern for the scenic qualities. Examples are areas seen from:

- Secondary roads and trails and use areas within, as well as to and from, National Parks, National Recreation Areas, Wildernesses, and other dedicated Wild Areas.
- Secondary recreation sites that fit the definition above.
- Examples of either primary or secondary routes which should always be assigned Sensitivity Level 1 are:
- All roads classified as "scenic highways."
- All roads and trails leading directly to major areas of interest such as National Parks, Wildernesses, major recreation composites, historic sites and areas, botanical sites, etc.

Level 2

Sensitivity Level 2 includes all seen areas from primary travel routes, use areas, and water bodies where fewer than one-fourth of the Forest visitors have a major concern for scenic qualities. Examples are all areas seen from:

- All Federal, State, and primary County or Forest systems not listed under Level 1.
- Known low-flying air routes (includes noncommercial leisure flying).
- Communities where a large portion of the population is directly related to performing Forest land management activities.
- Other primary uses not included under Level 1.

Level 2 also includes all seen areas from secondary travel routes, use areas, and water bodies where at least one-fourth, and not more than three-fourths, of the Forest visitors have a major concern for scenic qualities. Examples are all areas seen from:

- Secondary County and Forest road systems that fit the above definition.
- Secondary trail systems.
- All roads leading directly to secondary areas of interest and recreation composites.
- Secondary recreation areas (vista points, campgrounds, picnic grounds, etc.)
- Secondary uses of fishing, swimming, boating, and other active or passive recreation on or adjacent to water bodies such as streams, lakes, etc.
- Secondary geological areas.
- Secondary botanical areas.

- Secondary resorts.
- Secondary summer home tracts.
- Secondary historic sites.
- Areas of secondary importance for observation of wildlife.

Does not include travel routes and use areas of only occasional visitation.

Includes both existing and proposed (within 10 years).

Level 3

Level 3 includes all seen areas from secondary travel routes, use areas, and water bodies where less than one-fourth of the Forest visitors have a major concern for scenic qualities. (Level 3 does not include any areas seen from primary routes or areas.) Examples are areas seen from:

- All County and Forest road systems, not in Levels 1 or 2, which are either permanent or temporary.
- Secondary Forest trail systems used primarily for fire protection and other administrative uses.
- Recreation sites of little or no consequence (such as an occasional unimproved hunter camp).
- Streams with little or no fishing use.
- Secondary roads or use areas with only occasional use.
- All National Forest land not seen from any travel route, use area, or water body.

Foliage Quality Objectives

Lands proposed for suppression will be assigned a foliage quality objective. The three quality foliage quality objectives are:

RF - Retention of Foliage

PRF - Partial Retention of Foliage

MF - Modification of Foliage

These objectives are keyed to the values set forth in the sensitivity levels and distance zones. Each describes a different degree of acceptable change in color and texture from the natural landscape based upon the importance of esthetics.

Retention of Foliage (RF)

This visual quality objective provides for management of budworm defoliation at a level which is not readily evident. Color and texture changes will not be readily evident.

Partial Retention of Foliage (PRF)

Budworm defoliation remains visually subordinate to the characteristic landscape. Defoliation may introduce color and texture changes, but changes should remain subordinate to the visual strength of the characteristic landscape.

Modification of Foliage (MF)

Under the modification of foliage quality objective, defoliation may visually dominate the original characteristic color and texture of the landscape.

Protection Of Threatened, Endangered, And Sensitive Plants

A potential impact on threatened and endangered sensitive plants is a loss or reduction in insect pollinators. Information on insects responsible for pollinating these plants was not found, therefore, the potential impact of *B.t.* and/or carbaryl on these insects was not analyzed. Carbaryl, because of its effect on a broader range of insect species, has the most potential for posing an impact.

Protocols established in the Forest Service Manual (FSM 2670) for biological evaluations and consultation shall be part of all project level assessments. Documentation of adherence to these protocols will be provided in the project level assessment, and will minimize the potential for adverse consequences in all alternatives considered.

Protection Of Threatened, Endangered, And Sensitive Wildlife

All Forest Service actions that could affect threatened, endangered, or sensitive species, or their habitat, will be preceded by a documented biological evaluation (FSM 2670). The biological evaluation process should determine species/habitat presence in the project area and, if present, potential adverse effects. A review of existing recovery plans, if appropriate, would be part of the biological process. Mitigation measures or project modification would be planned as appropriate to ensure the proposed activity would not adversely affect the recovery of any threatened, endangered, or sensitive species.

Protection Of Range And Forage

Prior to any treatment, coordination with local (County) weed control boards and appropriate State (Oregon State Department of Agriculture) agencies will be made. This coordination will ensure that State and local efforts to control noxious weeds using biological agents will not be adversely affected by spruce budworm control agents.

Monitoring

Spray projects will have a written monitoring plan. The following purposes of monitoring will be considered in the plan and implemented:

- To measure the accomplishment of the project insect population reduction objectives. (Post application)
- To measure insecticide residue in domestic water supplies within applicable analysis units. (Post application)
- Operations monitoring to provide timely feed-back to the Incident Commander about the conduct of the operation.
- Spray deposit monitoring.
- *B.t.* sampling for clinically significant pathogens.
- Long-term monitoring of timber growth and yield of some selected forest stands. (Post treatment)
- Monitoring of effectivness of foliage retention in visually sensitive zones.

Personnel for each project area will be responsible for conducting water quality monitoring. A detailed plan will be developed for each project conducted.

In the event of an insecticide spill into a stream or body of water, water samples, drift net samples, and visual observations will be used to monitor insecticide distribution and environmental effects.

D: Western Spruce Budworm Management

APPENDIX D

Western Spruce Budworm Management

Western spruce budworm management consists of two main strategies; prevention and suppression.

Prevention

The time to recognize the threat of western spruce budworm is before outbreaks occur. Prevention strategies are designed to reduce forest susceptibility to attack and damage by western spruce budworm outbreaks over the long term by use of silvicultural treatments. Long-term management strategies to reduce forest susceptibility to western spruce budworm attack and damage should be considered and addressed in the Forest planning process (FSM 1922).

Suppression

Suppression objectives are aimed at providing short-term protection to forest stands during an outbreak. Two basic suppression tactics are used: population reduction and foliage protection. Both of these tactics use chemical and/or nonchemical insecticides.

The population reduction tactic is aimed at reducing western spruce budworm populations to as low a level as possible, thereby reducing defoliation and damage. Once populations are reduced, natural regulating factors may maintain populations at low levels for several years.

Under the foliage protection strategy, an insecticide is applied to areas where defoliation has occurred for many years, and one or more years of additional budworm feeding will cause unacceptable damage. The objective of the foliage protection strategy is to prevent substantial defoliation in the year of treatment, saving enough foliage to reduce damage such as visual effects and tree mortality.

Suppression Project Analysis Procedures

Suppression activities to reduce western spruce budworm damage during an outbreak should be considered on a case-by-case basis. The NEPA process (FSH 1909.15) should be followed when analyzing the possible need for suppression. The following should be included in the analysis:

Description Of Outbreak

Describe the nature and extent of the current outbreak. Forecast the expected course.

General Physiographic Description

Describe the general physiographic characteristics of the affected areas, as well as the terrain features and forest cover present. Discuss sensitive resources and features, if any. Include a map of the affected area.

Ownership Description

Identify all landownerships (Federal, State, private) involved in the affected area. Describe landowner objectives and responsibilities.

Description Of Resources At Risk

Describe the resources that have already been affected and those that will be affected in the future by the western spruce budworm outbreak. Resources such as timber, recreation, water, and visual quality may be affected. There may be conflicting resource objectives

between or within the ownerships involved; nevertheless, all appropriate objectives should be considered.

Formulation Of Suppression Alternatives

Budworm suppression alternatives should reflect issues identified in the scoping process (FSH 1909.15). Always analyze the following alternatives: no action, control using chemical insecticides, control using microbial insecticides, and vegetation manipulation. Some of these alternatives need substantial, detailed analysis, while others may not need to be considered in detail. For example, the vegetation manipulation alternative will usually be eliminated from detailed analysis because it is a long-term management strategy which is not directly comparable to suppression alternatives; long-term budworm management strategies should be considered as part of the Forest planning process (FSM 1922). Discuss the reasons for eliminating any analyzed alternative from detailed consideration. Devote substantial treatment to each alternative considered in detail.

Description Of Analysis Units

For analysis purposes, the affected area should usually be broken up into smaller units. Describe the units for which suppression alternatives are being analyzed. Explain the characteristics upon which the analysis units are based. Display these units on a map.

Evaluation Of Physical And Biological Effects Of Suppression Alternatives

Estimate the changes in physical and biological effects between the no-action and suppression alternatives. Consider effects on: regeneration and seed production; timber; recreation; fish and wildlife; and other aspects of the affected environment identified in the scoping process (FSH 1909.15). Estimate these effects relative to management objectives expressed in affected landowners' forest plans. For example, timber and wood fiber effects should be determined under the existing selection and schedule of timber management activities established by the Forest Plan, or by other Federal, State, or private landowner plans or stated objectives.

Evaluation Of Economic Effects Of Suppression Alternatives

Once physical and biological effects are determined, they must be expressed in economic terms. The purpose of the economic evaluation is to assess the costs and benefits associated with proposed suppression alternatives. Include both efficiency and local economic impacts in the analysis.

Local Economic Impacts

For each suppression alternative, describe changes in local income and employment, if any. The extent to which local economic impacts are addressed should be governed by the issues and concerns identified in the scoping process. A qualitative discussion of local economic impacts is often sufficient. When quantitative analysis is deemed necessary, methods such as input-output analysis and economic-base analysis can be used to estimate economic impacts.

Economic Efficiency

The economic efficiency evaluation assesses benefits and costs that can be expressed in monetary terms. Include only those effects identified as important during the scoping process. Describe changes in the value of outputs between the no-action and suppression alternatives. Changes in output values may be positive or negative.

Calculating Timber Economic Effects

A budworm outbreak on timber-producing lands usually disrupts management plans by affecting the timing and/or the magnitude of timber yields and associated management activities. The purpose of the timber economic evaluation is to determine how an outbreak will affect the economics of timber production over time. While circumstances will vary according to geographic area, timber species affected,

management practices, and other factors, the timber impact evaluation will usually include the following:

1. Description of timber harvest plans for each analysis unit under consideration. This would include the schedule of thinnings and final harvests prescribed in current management plans and objectives.

2. Projection of volume yield changes at each future harvest between no-action and suppression alternatives. Whenever possible, use spruce budworm damage model projections.

3. Determination of timber value changes between the no-action and suppression alternatives based upon projected timber resource prices.

4. Estimates of any future timber management and reforestation costs expected to vary between the no-action and suppression alternatives.

Calculating Nontimber Economic Effects

The scoping process will identify resource outputs and effects which must be measured to adequately address issues and concerns. It is not necessary to include each of these outputs explicitly in the economic analysis. The issues and concerns should help determine the outputs for which an economic evaluation is desirable. Consider the following:

1. When substantial uncertainty surrounds estimation procedures for nontimber economic effects, it may be more informative to discuss these effects qualitatively.

2. If economic evaluations for nontimber resources are performed, these analyses should be displayed separately from the economic evaluation of timber effects. Include a brief discussion of the reliability of the data used in the analysis.

3. When quantifying nontimber benefits, use values specified in the most recent Forest Plan (for National Forest System lands), or the most recent Resources Program and Assessment if local or regional values do not exist. Values from recent Regional or local studies may be substituted for Forest planning values if there is sufficient reason, fully documented, to do so.

Calculating Suppression Project Costs

Total suppression project costs must include all costs necessary to accomplish the objectives of the project, regardless of who pays. Costs of past activities and projects are considered sunk costs and are not included in project cost calculation. Consider the following:

1. Only those costs that change between the no-treatment and treatment alternatives should enter the economic analysis. Project costs should be identified by amount and time of occurrence. Future costs, as might be associated with a treatment strategy requiring multiple insecticide applications, must be discounted to their present values.

2. Some project costs cannot be known in advance with certainty. An example of an uncertain cost is that associated with an insecticide spill. Such an event would require cleanup costs. Include expected costs of an uncertain event whenever practical and where sufficient information exists to quantify both the probability and cost of the event. Compute expected costs by identifying the range of outcomes for chance events, determining the cost associated with each outcome, and weighing this cost by the probability or liklihood of the outcome's occurrence.

3. Economic efficiency decision criteria. Compute and display present net value (PNV) and benefit-cost ratio (B/C) for each suppression alternative. For a detailed discussion of the construction and use of these efficiency measures, see FSH 1907.17, Section 15.

Treatment Effectiveness

Pest population resurgence and reinvasion of a treated area will reduce the effectiveness of a pest control effort. Uncertainty surrounding control effectiveness can be dealt with either by incorporating effects due to resurgence and/or reinvasion directly into the resource impact projections, or by analyzing a strategy of multiple control treatments.

Discount Rates

Discount all future costs and benefits to their present value. Use 4 percent and 7.125 percent discount rates. Additional discount rates may be used for sensitivity purposes. See FSM 1971.71 for further discussion of discount rates.

Base Year For Analysis

Use the year in which the analysis is being conducted as the base year for all economic costs and benefits.

Stumpage Prices

Use stumpage prices from applicable Forest Plans for National Forest System (NFS) lands. Use local price data for non-NFS lands. If reliable local data are not available, use Forest Plan data for non-NFS lands. For the first decade of the analysis, recent timber price data may be substituted for Forest planning values if the Forest planning values differ substantially from recent timber sale prices. All volume impacts beyond the first decade will be valued at the long-term prices used in Forest Plans.

Real Cost And Price Projection

Use the same real price and cost projections that are used in the Forest Plans.

E: Economic Analysis of Commercial Timber Impacts in the Pacific Northwest Region

APPENDIX E

Economic Analysis Of Fiber Impacts Of Western Spruce Budworm In The Pacific Northwest Region

This appendix describes the general economic framework for determining costs and benefits of alternatives proposed for site specific management of a western spruce budworm outbreak. The methods described are for fiber production. The objective of the economic analysis is to provide land administrators with information to help judge the relative economic merit of alternative budworm management measures which protect fiber production. The results of such an analysis will be contained in a site specific environmental document.

Analytical technologies are never static. Techniques, assumptions, and data described in this appendix may change over time with the evolution of analytical techniques and acquisition of new knowledge. Changes in agency and government policy may also alter the analytical framework.

Economic Efficiency Analysis

From a broad viewpoint, the purpose of the economic efficiency (cost-benefit) analysis is to estimate the economic returns associated with alternative forest resource protection strategies proposed for a western spruce budworm infestation in Oregon and Washington. The efficiency analysis is conducted only for those costs and benefits that can be reasonably expressed in quantitative terms in accordance with Forest Service Handbook 3409.11-61.3. The evaluation will produce criteria to: (1) judge the economic merit of alternative management strategies for each analysis unit; (2) establish the most efficient level of funding; and (3), if treatment funds are insufficient to exhaust all economically viable investment prospects, provide one basis for selecting the best prospects.

The economic analysis is conducted in accordance with policy, procedures, and guidelines contained in Forest Service Manual Title 3400-Forest Pest Management, Forest Service Handbook 3409.11, and Forest Service Handbook 1909.17. In accordance with these, the No-action Alternative is selected as the baseline against which all other alternatives are compared. Each action alternative affords some measure of protection against forest resource output losses or other undesirable impacts caused by a western spruce budworm outbreak. The value (as expressed in base year dollars) of resource losses averted, minus the value of any adverse resource consequences, constitutes the benefits of investing in a pest management alternative. Costs are measured by the real value (net inflation) of resources expended in carrying out a management alternative. Once measured for a particular protection investment prospect, real benefits (net inflation) are weighed against costs to evaluate its economic viability either on its own account, or relative to competing protection alternatives.

Economic Efficiency Measures

The cost-benefit analysis provides two measures for comparing the economic efficiency of the forest protection project alternatives: present net value and benefit-cost ratio. These efficiency measures are prescribed in Forest Service Manual 3409.11. Present net value (PNV) represents the difference between discounted project benefits and costs. The benefit-cost ratio (B/C) is defined as the ratio of present value of benefits to present value of costs. Present value of either benefits or costs is determined by discounting all future values according to the prescribed discount rate(s).

Discount Rates

Present value of benefits or costs is determined by discounting future values according to the prescribed discount rate(s). The discount rates used in Forest Service evaluations are consistent with those used in long-term Forest planning as outlined under Title 1971 of the Forest Service Manual. As of 1989, the primary rate is 4 percent. To test the sensitivity of the results to higher discount rates, values of 7 1/8 and 10 percent are prescribed.

Analysis Unit and Stand Evaluation

The analysis unit (AU) is the fundamental geographic unit of analysis. It delineates an area, based on land management and entomological considerations, where a decision is to be made in regard to the forest protection alternatives. The uniqueness of individual analysis units requires that each be evaluated with regard to specific resource characteristics. For this reason, resource impacts are identified and evaluated by AU.

Economic evaluation of timber impacts is conducted at the stand level. This procedure conforms to Section 3422 of the Forest Service Manual. The particular application of stand analysis utilized here allows for economic sensitivity to differences in stand composition and management philosophy. For each pest management alternative, an evaluation of economic benefits and costs is made for the several stand categories. These categories express differences in stand structure, management intensity, age structure, host composition, species group, land manager, management philosophy, harvest scheduling, and local stumpage price variations.

Total AU benefits are determined by aggregating the benefits of treatment for all stands within an analysis unit. Total AU benefits for each forest protection alternative are then compared to the cost of protection to determine two measures of economic efficiency: present net value and benefit-cost ratio.

Major Assumptions

To conduct the economic analysis several assumptions must be made about insect population dynamics and the relationship between timber resource management and budworm outbreaks. These assumptions are intended to simplify for analysis purposes the extremely complex forest management and environmental setting of the budworm. Assumptions make both the biological and economic analysis tractable in the face of uncertain information.

The following assumptions are the most fundamental to the analysis and are made based on professional input from land managers and entomologists:

1. Analysis unit delineation, by taking advantage of geographical features which minimize insect movement, will reduce to a minimum the risk of insect reinvasion from adjoining infested, untreated areas.

2. Suppression efforts will be effective in reducing budworm populations to endemic levels.

3. Treatment of budworm early in an outbreak poses a risk of resurgence within the remaining time period of a regional outbreak.

4. The timing and damages of subsequent regional budworm outbreaks will be unaffected by the forest protection alternatives selected.

5. Preliminary fiber impact estimates indicate that their magnitude will not be sufficient to influence forest management activity schedules. The timing of volume impacts are assumed to be determined according to existing harvest schedules.

6. Opportunities for salvaging budworm-induced tree mortality are expected to be limited.

Wood Fiber Volume at Risk

Loss in wood fiber production presents the greatest resource value at risk to budworm defoliation. Hence, the major benefit to the treatment alternatives is the value of the gain (averting a loss) in wood fiber production.

The gain in wood fiber production is projected for fixed harvest dates using appropriate stand growth and budworm damage models. These models are combined to establish a baseline projection of fiber production (harvest volumes) for the no treatment alternative. Harvest volume projections are similarly made for each of the treatment alternatives.

The difference in harvest volumes between the baseline and a treatment alternative provides a measure of both the timing and quantity of fiber volume at risk (a more detailed discussion of this process is provided in Appendix G). It is this projected difference (no treatment and treatment) in future harvest volumes that is valued at projected stumpage prices and discounted to estimate the economic benefit (present value) of treatment.

Stumpage Prices and Projections

Future stumpage prices can significantly influence the value of fiber impacts. Because most timber impacts are not expected to be realized immediately, a need exists to project stumpage prices to the appropriate points in time. These projections are made from a baseline. Because of variations between locations and ownerships, baseline stumpage prices for eleven major species are computed for each landownership area within the scope of the current infestation. Stumpage prices also are scaled to reflected relative differences in value associated with tree diameter.

Stumpage prices for National Forests are based on a 5-year constant dollar average for the time period used in the current Forest Plans. On private ownerships

and other public lands, prices are based upon 5-year County data. For Oregon, these estimates are made by the Oregon State Department of Forestry from data made available by the Oregon State Department of Revenue. Estimates for Washington are provided by the Washington Department of Natural Resources.

Historically, the value of stumpage in the Pacific Northwest has increased over the long term at a rate faster than increases in the general price level. Estimates of historical real annual stumpage price increases range from close to zero, to the teens, depending upon species, time period, location, and estimation methodology. For the future, it is unlikely that a rate of real stumpage price increase can be forecast with certainty. For a particular individual, some rates will seem more likely to occur than others.

This uncertainty makes the task of conducting the economic analysis and providing decision-makers with meaningful information quite difficult. The site specific environmental analyses will be not attempt to settle upon a specific scenario for future stumpage price increases before conducting the analysis. Instead, the economic analysis will be conducted for several price-increase scenarios. These scenarios will cover, what is judged at the time of the analysis, to be the most likely range of outcomes over the long term.

Treatment Costs

The major cost item in the cost-benefit analysis is that associated with application of an insecticide. An estimate of expected per acre treatment cost for each alternative must be made before conducting the cost-benefit analysis. Final cost figures are estimated by means of statistical, engineering, and extrapolation models used to forecast individual cost components. Examples of the cost components that may be involved in this process are:

- Insecticide and carrier
- Spray aircraft
- Observation aircraft
- Insecticide transport, mixing and storage
- Boundary marking
- Dye
- Environmental monitoring
- Laboratory analysis
- Pre and post treatment population sampling
- Salaries and wages
- Per diem and travel expenses
- Vehicle and equipment expenditures
- Facility rentals or construction
- Utilities
- Data Processing
- Materials and supplies
- Other

The value of individual cost components and, hence, total per acre treatment cost will vary from one year to the next and across project locations. They may also vary by alternative. Factors which cause variation include items such as contract specifications, local market conditions, regional and individual project size, application methods, and a variety of site specific conditions.

Substantial variation in treatment costs was experienced during the 1987 and 1988 suppression projects in the Pacific Northwest. Per acre costs ranged between $18.00 and $38.00 per acre. The major contributor to this variation, accounting for over 50 percent of total cost, is the cost of application and observation aircraft. To provide decision-makers with information on the implications of uncertainty surrounding treatment cost estimates, the economic analysis is conducted with three estimates of cost: 1) a most likely estimate, 2) a low estimate, and 3) a high estimate.

Estimating per acre treatment cost or a range of costs for a specific analysis unit cannot be made until certain site and regional specific project data become available. The site specific environmental analysis will estimate treatment costs for each analysis unit.

Treatment and Protection Costs

A distinction is made between treatment and protection costs. This disparity figures prominently in determining the economic efficiency criteria. Total expected protection costs over the life of the outbreak may exceed initial treatment costs. The magnitude of the difference will depend upon the projected need for treatments later in the infestation.

The expectation of incurring future treatment costs is based upon the proportion of acres in an analysis unit that have been infested less than 4 years. A unit which has been infested for 4 or more years in its entirety, is projected to need only one treatment before the end of the infestation. Recently infested units are projected to need two treatments to effect adequate protection until the outbreak collapses. Units which have a mixture of acres at different years of the infestation are projected to need a second treatment with a probability proportional to the number of acres that have been infested 3 or less years.

Total expected protection cost is used in the computation of economic efficiency statistics: present net value (PNV) and benefit-cost ratio (B/C). Where multiple treatments are expected for an analysis unit,

total treatment costs includes the expected cost of a second treatment.

Reporting the Results

Each site specific environmental analysis will present a general discussion of economic and timber resource impacts discovered by analysis. There is no standard format for presenting this discussion. However, specific results of the economic analysis are summarized by analysis unit in two general formats. These formats may show some variation from year to year to accommodate site specific considerations and new analysis considerations.

The first format, as shown by example Table E-1, displays for each analysis the benefit-cost ratio (B/C) and present net value (PNV) for alternative real annual stumpage price increase scenarios. The purpose of this format is to show the sensitivity of economic results to alternative assumptions about future stumpage prices. Table E-1 is repeated for each combination of discount rate and treatment cost considered by the site specific analysis.

The second format will follow the general structure shown in Table E-2. This table displays the results of sensitivity analysis for discount rates. At present, Forest Service Manual Title 1971 requires conducting the economic analysis with alternative discount rates. For a site specific environmental assessment, the economic results would be presented in a table similar to Table E-2 for the alternative discount rates prescribed at the time the analysis is conducted. Contained also in the table is an estimate of expected loss of harvest volume without treatment. Table E-2 is repeated for each combination of real stumpage price increase and treatment cost considered by the site specific analysis.

Table E-I

Economic Statistics by Real Annual Stumpage Price Increase *

(Discount rate: ____ & Treatment cost: ______)

ANALYSIS UNIT	LAND MANAGER	ACRES TREATED	TREATMENT COST	ANNUAL % REAL STUMPAGE PRICE INCREASE 0%		1%		2%		3%	
				(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)
TOTAL											

* Treatment cost includes an adjustment for multiple treatments.

Table E-II

Economic Projections by Alternative Discount Rate

(Treatment cost: ______ & Real stumpage increase: ____)

ANALYSIS UNIT	LAND MANAGER	ACRES TREATED	VOLUME LOSS	TREATMENT COST	DISCOUNT RATES 4%		7-1/8%		10%	
(NAME)	(CODE)	(ACRES)	(MBF)	(DOLLARS)	(PNV)	(B/C)	(PNV)	(B/C)	(PNV)	(B/C)
TOTAL										

* Treatment cost includes an adjustment for multiple treatments.

F: Human Health and Environmental Risk Assessment for the Use of Insecticides

APPENDIX F

Human Health and Environmental Risk Assessment for the Use of Insecticides and a Biological Control Agent in Western Spruce Budworm Suppression Program Conducted by the USDA Forest Service in Washington and Oregon

Prepared for the Forest Service under Contract
Number 53-3187-4-22

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Introduction

Purpose

The purpose of this analysis is to assess the risks to human health and the environment (including fish, wildlife, and other nontarget organisms) of using three chemical insecticides (acephate, carbaryl, and malathion) and a biological control agent, *Bacillus thuringiensis (B.t.)* for controlling western spruce budworm on National Forest System lands in USDA Forest Service Region 6 (Washington and Oregon). This risk assessment is a supplement to the Forest Service Environmental Impact Statement (EIS) on suppression of western spruce budworm. The EIS analyzes the environmental impacts of using various alternatives for suppressing western spruce budworm in the Pacific Northwest.

The risk assessment also addresses the human health and environmental risks of a number of chemicals (for example, the insecticide carrier diesel oil and the formulation ingredients kerosene and mineral oil) associated with the application of the insecticides and the biological control agent. The analysis also considers N-nitrosocarbaryl, a carcinogenic metabolic product of carbaryl, that may form in the stomach after oral exposures and methamidophos, a toxic degradation product of acephate.

Overview of the Risk Assessment

The risk assessment examines the potential health effects to all persons who might be exposed to any of the insecticides and associated chemicals as a result of activities related to spruce budworm spray programs. People potentially at risk are considered to belong to two groups. The first group--workers--includes applicators, supervisors, and other personnel directly involved in the application of insecticides. The second group--the public--includes forest visitors or nearby residents who could be exposed through the drift of insecticide spray droplets, through contact with sprayed vegetation, or by eating food items, such as berries growing in or near forests, game animal meat or fish containing insecticide residues, or by drinking water that contains such residues.

The risk assessment also considers effects on wildlife and aquatic species from the control insecticides by comparing estimated exposures to lethal levels found in laboratory studies.

The analysis of the potential human health effects of the use of insecticides for spruce budworm suppression was accomplished using the methodology of risk assessment generally accepted by the scientific community. In essence, the risk assessment consists of comparing doses that people may get from applying the insecticides (worker doses) or from being near an application site (public doses) with doses shown to cause no observed adverse effects in tests on laboratory animals.

A number of factors contribute to the uncertainty in this process of judging risks to human health based on laboratory animal studies. First, the reference levels established in the laboratory are the result of tests on laboratory animals, particularly rats and mice, in which dose levels produce no observed effects. To allow for the uncertainty in extrapolating from these no-observed-effect levels (called NOEL's) in laboratory animals to levels deemed acceptable for humans, safety factors are used. The generally accepted factors (NRC, 1986) are 10 for moving from animals to humans (between species variation) and another 10 to account for possible variation in human responses (within species variation). This 10 times 10, or hundredfold, safety factor means that the laboratory NOEL dose reduced one hundredfold would normally be considered an acceptable or reasonably safe dose. In this risk assessment, a margin of safety (MOS) or "hazard level to exposure level" ratio has been calculated for each estimated dose by dividing the animal NOEL by the estimated dose. The computed MOS is then compared to the hundredfold safety factor to judge the risks of toxic effects.

A second area of uncertainty lies in evaluating the risk to humans of exposures that may occur once or perhaps a few times in a person's lifetime (accidental worker doses and all doses to the public fall in this category) by comparing those human doses to levels of the chemical that produced no ill effects in laboratory animals--even though the animals are exposed every day of their lives. This risk assessment uses the MOS

approach discussed above in comparing one-time human doses to lifetime animal doses in all of these cases, even though this leads to an exaggeration of the risks.

A different approach is used to assess the risks to humans of chemicals that may cause cancer or heritable mutations because such chemicals are assumed to have no comparable margin of safety, so some risk exists even at extremely low doses. Human epidemiology cannot be used in assessing risk to heritable genetic damage, and rodent models are difficult to quantify (Ehling, 1988). In this case, a cancer potency value, which expresses the probability of developing tumors at increasing dose levels, is taken from laboratory animal studies and adjusted for the differences in body weight between the laboratory animals and humans. This potency value multiplied by an estimated human lifetime dose provides an estimate of human cancer risk.

A third area of uncertainty involves the estimation of the human doses likely to occur in insecticide use. This risk assessment has been designed to overestimate doses to err on the side of safety. In reality, workers are likely to experience a range of exposures because they work with the chemicals routinely. However, standard safety practices and the use of protective clothing will normally reduce their actual dose levels far below those estimated in this analysis. The same is true of the doses from any spraying or spill accidents that might occur because the normal procedure would be to wash immediately. In addition, no member of the public is likely to receive as high a dose as estimated in this risk assessment, again because normal safety practice and the remoteness of most treated areas limit the possibility of the public's receiving any dose at all. Furthermore, the public doses estimated here exaggerate the amount they could receive. No insecticide degradation is assumed to occur, the public is not assumed to wash themselves or their food items after a spraying, and they are assumed to consume water that has received insecticide from drift or a spill immediately after the event. Thus, the way in which exposures are estimated and risks evaluated in this risk assessment tend to exaggerate the real risks.

This risk assessment includes analyses of a range of possible exposures--from realistic to extreme--resulting from insecticide application by using three types of scenarios. First, typical application scenarios (routine-typical) are used to estimate the doses to workers and to members of the public who may be nearby that may reasonably be expected to occur during routine operations. Second, worst case application scenarios (routine-worst case) are used to give very high dose estimates that are not likely to be exceeded except in the case of an accident. Third, accident scenarios are used to estimate doses to workers and the public that may result from direct exposure to the insecticide spray mix or concentrate, or from drinking water into which a truckload of insecticide mixture or a drum of insecticide concentrate has been spilled.

Structure of the Risk Assessment

This risk assessment employs three principal analytical elements described by the National Research Council (NRC, 1983) as necessary to characterize the potential adverse health effects of human exposures to existing or introduced hazards in the environment: hazard analysis, exposure analysis, and risk analysis. The relationships among these three components are illustrated in figure F1-1. Each component is briefly described below.

- Hazard Analysis requires gathering information that is used to determine the toxic profile of each insecticide. Human hazard levels are derived primarily from the results of laboratory experiments on animal models, such as rats, mice, and rabbits, supplemented where appropriate with information on human poisoning incidents, field studies of other organisms, and data on chemical structure. (A fourth analytical element--dose-response analysis--is subsumed under the hazard analysis.)

- Exposure Analysis involves estimating single and multiple exposures to persons and wildlife potentially exposed to the insecticides, determining the doses likely to result from those estimated exposures, and determining the number and characteristics of persons in the exposed populations.

- Risk Analysis requires comparing the hazard information with the dose estimates and examining their probabilities of occurrence to estimate the likelihood and severity of health effects to individuals under the given conditions of exposure.

The discussion that follows describes briefly how each component in the structure was addressed in this risk assessment.

Hazard Analysis

- Identify what kinds of health effects have been observed under experimental laboratory conditions and at what levels of exposure
- Identify any health effects that have been observed in humans
- Determine median lethal dose (LD_{50}) for acute effects from laboratory rat study
- Determine lowest no-observed-effect levels (NOEL's), if possible, for general chronic toxic effects, reproductive effects, and birth defects
- Determine whether the insecticide has the potential to induce cancer or mutations
- Identify data gaps in toxicity information

Exposure Analysis

- Identify people exposed
- Identify routes of exposure
- Estimate how much each person would receive by each exposure route using both realistic and worst case scenarios
- Estimate frequency and duration of exposure
- Calculate doses

Risk Analysis

- Compare doses to NOEL's and LD_{50}'s and discuss probability of acute and chronic effects for routine and worst case scenarios
- Conduct worst case analysis for cancer risk
- Qualitatively evaluate risk of heritable mutations

Figure F1-1—Components of the risk assessment process

Hazard Analysis

The insecticides that the Forest Service is considering for the western spruce budworm suppression program include acephate, carbaryl, and malathion and the biological control agent *B.t.* The hazard involved in the use of each of the insecticides was determined in a thorough review of available toxicological studies. When no studies were identified for a particular toxicity end point, for example, mutagenicity, these data gaps were identified; a worst case analysis for this endpoint is in section F4. Scientific uncertainty about the results of particular studies also is discussed. The hazard analysis is presented in section F2.

Exposure Analysis

To estimate the potential human exposures to the insecticides, various aspects of the Forest Service's western spruce budworm suppression program in Washington and Oregon that use insecticides were examined. The analysis considered the characteristics of the spraying operations (including application methods, application rates, size and configuration of spray areas, project design features, and mitigation measures), the human populations likely to be affected, and the routes of exposure for humans in both routine operations and as a result of accidents.

Insecticide Spraying Operations. The insecticides examined in this risk assessment are applied aerially, using fixed-wing or helicopter aircraft. The size of the program may vary in any given year, as described in the EIS. The annual program would involve a limited number of large projects and many small projects, ranging from one to many separate treatment units.

Individual treatment units within a project can range from 50,000 to more than 100,000 acres. The average number of acres to be sprayed by one helicopter in 1 day may be approximately 2,500. Therefore, with an average of 10 pilots flying per day, a total of 25,000 acres may be sprayed in 1 day. However, no more than 5,000 acres within a single watershed would be sprayed in 1 day.

The area treated with various insecticides in 1985, the last time a major spray effort occurred, was approximately 500,000 acres--less than 2.3 percent of the possible 21,746,000 acres of National Forest System land in Region 6. The main body of the EIS and section F3 of this risk assessment contain further details about these operations.

Affected Populations. In calculating the potential doses to persons at risk from insecticide applications, two populations were considered: workers and the general public. Workers included personnel directly involved in the spray operations: the batch truck operator, mechanics/laborers, load checkers, spray pilots, observation pilots, aerial observers, ground observers, the spray assessment crew, and the biological evaluation crew. The public included forest visitors and nearby residents who may be directly exposed to insecticide as a result of drift, by contact with vegetation with insecticide residues, or by being accidentally sprayed. The public may be indirectly exposed by eating food or drinking water containing insecticide residues.

Routine Exposure Scenarios. This risk assessment examines the health effects of exposure to an individual insecticide treatment, as well as the cumulative effects of exposure over a number of years. To represent the range of doses under normal operating procedures, routine-typical and routine-worst case application scenarios were used. For members of the public, the scenarios involved exposure from various routes, including oral (eating meat, fish, berries, or garden vegetables or drinking water), dermal (vegetation contact and drift exposure), and inhalation (drift exposure). Cumulative exposures to hypothetical hunters and fishermen from several exposure routes also were calculated.

Worker exposures were estimated by task. Tasks included pilot, mixer/loader, ground-based observer, card checker, and efficacy evaluation team member.

Cumulative lifetime doses were estimated for the analysis of lifetime cancer risk by using information on average and maximum treatment days per year and information on average and maximum number of years exposed for workers and for the public. Although little data are available, synergistic effects and exposures to mixtures of insecticides also were evaluated.

Accident Exposure Scenarios. Because all human activities involve the possibility of error, the use of insecticides in western spruce budworm suppression involves the possibility that humans may inadvertently receive unusually high exposures to the insecticides because of accidents.

To examine the potential health effects that could occur in an accidental situation, a number of accident scenarios were analyzed. Exposures analyzed included direct aerial application of insecticide on a person, spills of concentrate or insecticide mix on workers during mixing and loading, spills of insecticide into drinking water supplies, and direct spraying of garden vegetables.

Risk Analysis

Human health risks of the western spruce budworm suppression program were evaluated by comparing the doses of workers and the general public calculated for routine operational and accidental exposure scenarios to the laboratory- determined toxicity levels described in the hazard analysis.

Risks of acute and chronic threshold effects are evaluated by comparing estimated doses to toxicity reference levels derived from NOEL's in laboratory animal studies, using a calculated MOS. Risk increases as the estimated dose approaches the laboratory toxicity level--that is, as the MOS decreases.

Nonthreshold risk, that is, the potential for these insecticides to cause cancer and mutations, was evaluated differently than threshold risk. The risk of cancer at a given level of exposure, based on the estimated average daily exposure over a 70-year lifetime, was derived for each insecticide from laboratory animal data on tumor incidence at increasing dose levels. These data were corrected for species differences, and the risk of cancer was calculated for various categories of people who may be exposed to the insecticides through various routes.

The risks of heritable mutations are discussed based on the weight of evidence from available test data on bacteria, yeasts, plants, mammalian cells in culture, and whole animals. When no test data are available for an insecticide, a worst case assumption is made that the insecticide is mutagenic, and that risk is then based on the insecticide's estimated cancer risk. This approach is discussed in detail in a later section but it assumes that genotoxic agents would be detected as carcinogens from lower exposures than would be required to induce heritable damage in germ cells.

Cumulative risk for individuals is discussed in terms of lifetime exposures to a given insecticide for workers and for members of the public. Risk of synergistic effects is discussed in terms of the available evidence of enhanced toxicity in mixtures of two or more insecticides. Risk to more highly sensitive individuals who may be affected at extremely low exposure levels is discussed qualitatively in terms of the likelihood of a sensitive individual being exposed.

Worst Case Analysis Requirements

As indicated earlier, this document is a supplement to the Forest Service EIS on the suppression of western spruce budworm and has been prepared pursuant to the requirements of the National Environmental Policy Act (NEPA) and the Council on Environmental Quality (CEQ) regulations for implementing NEPA.

Data Gaps

This risk assessment identifies a number of information data gaps, including the following:

- Field studies on exposure to workers for the three insecticides.
- Information on public exposure to forestry-use insecticides.
- Field data on residue levels in plants and animals most likely to be found in and around treatment areas for some of the insecticides.
- Mutagenicity study data for malathion (chromosome aberration) and carbaryl (DNA damage).
- Teratogenicity study data for malathion and reproduction study data for acephate and malathion.
- Chronic rat and dog toxicity and mouse oncogenicity study data for malathion.
- Toxicity information on the synergistic effects from exposure to more than one insecticide.

- Toxicity information on the cumulative effects from exposure to forestry-use insecticides, other pesticides, and/or other chemicals.

- Toxicity, infectivity, and exposure information for *B.t.* (var. kurstaki) to supplement the data from the history of its use.

These information gaps are important in deciding what is the best alternative for action; however, the cost of obtaining this information is an important consideration.

The following are estimates of the costs of filling the specific data gaps listed above (Hazelton, 1988):

- Worker exposure studies would cost approximately $200,000 per chemical.

- No acceptable protocol is available for measuring all of the various routes of exposure to the public, but these studies would be more expensive than the worker exposure studies.

- The costs of measuring residues in plants and animals would range from $50,000 to $100,000 per chemical per plant or animal.

- The mutagenicity and chromosomal studies for malathion and carbaryl would cost approximately $75,000 per chemical.

- The teratogenicity study on malathion would cost approximately $60,000.

- The reproduction study on acephate would cost $150,000.

- The rat and dog chronic toxicity tests for malathion would cost approximately $400,000.

- The mouse oncogenicity study for malathion would cost between $350,000 and $400,000.

- Synergism studies would be extremely expensive because of the great number of tests that would be necessary to evaluate interactions between these insecticides and all other forestry-use pesticides.

- The costs of toxicity and infectivity studies on *B.t.* are not available but should be of the same order of magnitude as the chemical tests.

The overall cost of conducting the studies to fill the data gaps is considered exorbitant considering the limited funds available to the Forest Service. In addition, the time necessary to perform and evaluate most of these tests is more than 2 years, which would seriously delay the continuation of the western spruce budworm suppression program. Many of the desired toxicological studies have already been requested by EPA, and the results of these studies will be considered when they become available. In addition, both agencies have ongoing research and monitoring programs to examine various aspects of insecticide treatment, and these results will be considered as they become available.

Because the cost of filling the data gaps is considered exorbitant, a worst case analysis was conducted for those areas where information is unavailable or where there is uncertainty. The worst case scenarios involving routine insecticide application operations consist of those combinations of parameters, such as treatment unit size, duration of exposure, application rate, application equipment, and meteorological conditions, that give the highest reasonable exposure value. Extreme exposures resulting from accidents were also evaluated, including those that result from direct spills of concentrate on workers' skin, the direct spraying of an individual, and contamination of a public drinking water supply by an insecticide spill.

The worst case analysis for the mutagenicity of an insecticide for which there are no data or where there are some positive short-term tests for mutagenicity assumed that the insecticide could cause heritable mutations. In establishing genetic risk for these compounds using a worst case scenario, the risk of heritable mutations was assumed to be no greater than the risk of cancer for a given insecticide. This assumption is based on analysis of existing data for chemicals with both cancer and heritable mutation bioassays.

The worst case analysis for insecticides that had either positive cancer studies or for which there is scientific uncertainty assumed that these chemicals could cause cancer. A conservative cancer potency value for a chemical was computed by using the highest rates of tumor formation found in the available animal studies. A conservative model for estimating human cancer rates from tumor rates in laboratory animals also was used. The worst case analysis for synergistic effects assumed that these effects could occur. The probability of these effects occurring was considered low.

EPA has identified the data gaps shown in section F2, table F2-11, in accordance with the registration guidelines under the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. Although there are data gaps or areas of uncertainty for some of the insecticides in this risk assessment, there is a large body of existing data useful for predicting the behavior and toxicity of these insecticides, including the following:

- Worker exposure studies with EPN (ethyl p-nitrophenyl thionobenzene phosphate) insecticide.

- Studies on drift of the insecticide trichlorfon.

- Residue information for the insecticides in plant and animal tissues.

Organization of this Risk Assessment

Section F2, the hazard analysis, summarizes and discusses the toxic properties of each insecticide, including the cancer potency of the known or suspected carcinogenic insecticides. Section F3, the exposure analysis, describes the methods used to estimate levels of exposure and resultant doses to workers and the public and presents summary tables and discussions of estimated acute and long-term doses. Section F4, the risk analysis, presents the comparison of the results of the exposure analysis with the toxic effect levels set forth in Section F2. Section F4 also discusses cancer risk, given estimated lifetime doses to workers and the public. Attachment F-A presents a discussion of the environmental fate properties of the insecticides. Attachment F-B discusses the analysis of the risk of heritable mutations.

Section F2

Hazard Analysis

Purpose

The purpose of this hazard analysis is to determine the potential hazard to humans and nontarget organisms from four insecticides, two inert ingredients, two breakdown products, and a pesticide carrier considered for use in Region 6 for the suppression of western spruce budworm. This section presents available toxicological information for the three chemical pesticides malathion, carbaryl, and acephate, and a microbial pesticide, *Bacillus thuringiensis*. Because carbaryl is commercially formulated (as Sevin® 4-Oil) with kerosene and because diesel oil is used as a carrier in the application of Sevin® 4-Oil, the hazards of kerosene and diesel oil also are addressed. (Petroleum oils and diesel oil are listed by EPA as inerts of toxicological concern.) Mineral oil, a formulation ingredient in *Bacillus thuringiensis*, is not an inert of concern and will be addressed briefly in this report. The hazards associated with methamidophos, a degradation product of acephate and N-nitrosocarbaryl, a metabolic reaction product of carbaryl, also are analyzed in this section.

The first part of this section describes the sources of toxicity information used in the hazard analysis. The second part explains the terminology concerning laboratory toxicity testing used later in describing the toxic properties of the insecticides. Scientific and technical terms are defined in the glossary. The remainder of the section presents the hazards to humans, wildlife and beneficial insects, and aquatic organisms.

Sources of Toxicity Information

The toxicity of the three insecticides (malathion, carbaryl, and acephate) to laboratory animals, humans, wildlife, and aquatic species is described in detail in the background statements prepared for the Animal and Plant Health Inspection Service (APHIS) by Roy F. Weston, Inc. (Dobroski, 1985; Dobroski and Lambert, 1984; Lambert, 1985). Most toxicity data presented for *Bacillus thuringiensis* were obtained from a background statement prepared for the Forest Service by Mitre Corporation (Sassaman, 1987). Toxicological data for diesel oil and kerosene were obtained from a background statement that LABAT-ANDERSON Incorporated prepared for the Forest Service.

Much of the data on pesticide toxicity have been generated to comply with the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended (7 U.S.C. 136 et seq.), which establishes procedures for the registration, classification, and regulation of all pesticides, including insecticides. Toxicity levels and related information from the series of studies submitted for registration are compiled by EPA in summary tables, called tox one-liners, which are available on request from EPA's Freedom of Information Act Office. EPA has compiled "science chapters" on carbaryl and acephate, which also are available from EPA.

An extensive literature search was funded by the Forest Service to ensure that all of the relevant available information was used in this risk analysis. That search was updated to make the document current for information available as of February 1, 1989. Whenever possible, studies that have been reviewed and evaluated by EPA were used to select toxicity reference levels for use in this risk assessment. In no cases were studies used that have been determined invalid by EPA.

Hazard Analysis Terminology

Judgments about the potential hazards of pesticides to humans are necessarily based on the results of toxicity tests on laboratory animals. These toxicity test results are supplemented by information on actual human poisoning incidents and effects on human populations when they are available. The discussion of laboratory toxicity testing that follows is extracted from Doull et al. (1980), Hayes (1982a), and Loomis (1978).

Laboratory Toxicity Testing

Test Animal Species

Laboratory test animals function as models of the likely effects of the pesticides in humans. Ideally, the selected test animal should metabolize the compound the same as a human and should have the same susceptible organ systems. On a body weight basis, humans generally are more susceptible to the compound's effects than experimental animals, by an approximate factor of 10 (Doull, 1980). Results of such tests then can be directly extrapolated to humans, with some adjustment for differences in body weight and body surface area. Although no test animal has proved to be ideal, a number of species, in particular, rats, mice, rabbits, hamsters, guinea pigs, dogs, and monkeys, have proved to be consistent indicators for certain types of toxicity tests, routes of administration, and types of chemicals.

Toxic Endpoints and Toxicity Reference Levels

Toxicity tests are designed to produce specific toxic endpoints, such as mortality or carcinogenicity, and toxicity reference levels, such as a no-observed-effect level (NOEL). In addition to the test animal used, toxicity tests vary according to duration of exposure, route of administration, dose levels, frequency of exposure, number of test groups, and number of animals per group. Toxicity tests also vary according to whether the effect in question is assumed to be a threshold or nonthreshold effect.

Threshold and Nonthreshold Effects

The objective of most toxicity testing is to establish threshold levels that can be adjusted by a safety factor to establish acceptable levels of exposure. Threshold levels are levels of exposure that produce no toxic effects but, when exceeded, may produce an adverse effect in the test organism. Examples of toxic effects include pathologic injury to body tissue; a body dysfunction, such as respiratory failure; or a toxic endpoint, such as birth defects. Chemicals are generally thought to possess no such threshold level for cancer and mutations; thus, these toxic endpoints may occur (with a certain level of probability) even in the presence of extremely small quantities of the substance.

Duration of Toxicity Tests

The duration of exposures in toxicity tests range from short-term acute tests to longer subchronic studies to chronic studies that may last the lifetime of an animal. Acute toxicity studies involve administration of a single dose to each member of a test group (either at one time or in a cumulative series over a short period, usually less than 24 hours). Subchronic toxicity studies, used to determine the effects of multiple doses, usually last from 3 to 90 days, but generally less than one-half of the lifetime of the test animal. Most subchronic toxicity tests last 90 days. Chronic studies, also used to determine the effects of multiple or continuous doses, normally last 2 to 7 years depending on the test species, but generally more than one-half of the test species' lifetime.

Routes of Administration

Routes of administration include oral by means of gavage (forced into the stomach with a syringe through a plastic tube) or fed in the diet; dermal (applied to the skin); inhalation (through exposure to vapors or aerosol particles); and parenteral (injection other than into the intestine), such as subcutaneous (injected under the skin), intraperitoneal (injected into the abdominal cavity), and intravenous (injected into a vein). The selection of the route of administration of a particular test material is based on the probable route of exposure to humans. Oral, dermal, and inhalation doses most nearly duplicate the likely routes of human exposure. Parenteral doses are used in testing drugs but are not widely used in pesticide toxicity testing because they bypass the test animal's natural protective mechanisms and sensitive systems such as the skin and lungs.

Dosage units may be expressed in several ways, which include the following: amount of test material based on the body weight of the organism (that is, milligram of test material per kilogram of body weight), as parts per million (ppm) in the diet of the test organism, or in milligrams per liter (mg/L) in the air the organism breathes or in the water the organism drinks.

Dosing Levels

Dosing in longer term studies is generally administered in the diet, with specified amounts in parts per million in the food. The known weight of the test animals over the test period is used to convert parts per million in the diet to milligrams of chemical per kilogram of body weight per day (mg/kg/day) for extrapolation to humans. In most chronic toxicity studies, at least three dosing levels are used in addition to a zero-dose or control group. In general, the control group animals are administered the vehicle used in the test material administration. In a dietary study, the basal feed would serve as the vehicle. Test organisms are typically dosed in groups of 8 to 50 animals per sex.

Types of Toxicity Studies

Acute Toxicity Studies

Acute toxicity studies are used to determine the toxicity reference level, known as the median lethal dose (LD_{50}), which is the dose that kills 50 percent of the test animals. The lower the LD_{50} indication of potency, the greater the toxicity of the chemical. The LD_{50} toxicity categories used in this risk assessment are those of the EPA classification system that uses rat LD_{50}'s, as shown in table F2-1. Because mortality is the intended toxic endpoint, dose levels usually are set relatively high in acute studies. Overt indications of toxicity exhibited by the animals are recorded throughout the study, and tissues and organs are grossly examined for abnormalities following sacrifice at the end of the test. The rat is most commonly used for oral LD_{50}'s. Rabbits are used most often to determine dermal LD_{50}'s.

Because death represents the extreme toxic consequence for judging possible effects from the use of pesticides, the policies of regulating agencies regarding acceptable intake levels of these chemical compounds are most often based not on acute studies, but rather on toxicity tests designed to find the dose level that produces no effects in the animal species tested.

Subchronic Toxicity Studies

Subchronic studies are designed to determine the toxicity reference level called the no-observed-effect level (NOEL), which is the highest dose level at which no toxic effects are observed. Subchronic studies, normally employing lower dose levels than acute studies, provide information on systemic effects, cumulative toxicity, the latency period (the time between exposure and the manifestation of a toxic effect), the reversibility of toxic effects, and appropriate dose ranges to be used in chronic tests. The adverse effects may include overt clinical signs of toxicity, reduced food consumption, abnormal body weight change, abnormal clinical chemistry or hematology, and/or macroscopic or microscopic abnormalities in the test organism's tissue.

Testing of a biological pest control agent includes assays focused on identifying the possible infectivity of the microbe employed. Cultures are introduced into selected sites in the test species (for example, the gastrointestinal tract, brain, respiratory tract). Any evidence of toxicity or infection resulting in mortality to the test species would trigger attempts to isolate the agent from the treated organism.

Chronic Studies

Chronic studies, like subchronic studies, can be used to determine systemic NOEL's. If all other variables of the test are equal, the longer the study from which the NOEL is derived, the more confidence there is in the predictive accuracy of the resulting value. However, chronic studies are even more important in identifying chemicals that produce delayed toxicity, such as carcinogenicity.

Teratogenicity Studies

Teratogenicity studies (also called developmental studies) determine the potential of a chemical to cause malformations in an embryo or a developing fetus between conception and birth. These studies are generally performed on rats or rabbits, and they may be conducted over several generations. The rats are monitored for functional as well as structural deformities. A range of doses is employed to determine the teratogenic NOEL.

Table F2-1—Acute toxicity classification and acute toxicities of the three chemical insecticides

Toxicity category[a] (label signal words)	Insecticide or other chemical substance	Oral LD_{50} for rats (mg/kg)	Equivalent human dose
IV Very slight		5,000 - 50,000 (range)	More than 1 pint
	Sugar	30,000	
	Ethyl alcohol	13,700	
III Slight (caution)		500 - 5,000 (range)	1 ounce to 1 pint
	Table salt	3,750	
	Bleach	2,000	
	Aspirin, Vitamin B_3	1,700	
	Acephate	866	
II Moderate (warning)		50 - 500 (range)	1 teaspoon to 1 ounce
	Malathion	370	
	Carbaryl	270	
	Caffeine	200	
I Severe (danger - poison)		0 - 50 (range)	1 teaspoon or less
	Nicotine	50	
	Strychnine (rodenticide)	30	
	Botulinus toxin	0.00001	

[a]Category, signal word, and LD_{50} ranges are based on a classification system that EPA uses for labeling pesticides.

Source: Adapted from Maxwell (1982).

Reproductive Studies

Reproductive toxicity studies are conducted to determine the effect of a chemical on reproductive success, as indicated by fertility (production of reproductive cells), fetotoxicity (direct toxicity to the developing fetus), and survival and weight of offspring. Other end points, such as teratogenicity, can be assessed, but these are the most common.

These tests are performed at doses similar to those used in teratogenicity studies and typically use rats. Both male and female rats are exposed to the chemical for a number of weeks before mating. The number of resulting pregnancies and viable offspring produced are recorded. Tests may be conducted over two or three generations.

Carcinogenicity Tests

Carcinogenicity tests (cancer studies or oncogenicity studies) are conducted to determine the potential for a chemical to cause tumors when administered to an animal over its lifetime. Testing is normally conducted by placing the chemical in the diet of rats or mice for approximately a 2-year period.

The cancer potency of a chemical is defined as the increase in likelihood of getting cancer from a unit increase in the dose of the chemical. The cancer potency value reflects the probability of getting cancer sometime in a person's lifetime for each mg/kg/day. The cancer potency is derived from tumor data generated in laboratory animal studies.

Several assumptions have been made in estimating cancer potencies. First, it is assumed that any dose, no matter how small, has some probability of causing cancer. This is an assumption based on the nonthreshold hypothesis that postulates that even a single, extremely small dose may be enough to trigger cancer. Second, one of the principal areas of scientific controversy in cancer risk assessment is extrapolating the cancer potency line from the high doses used in animal studies to the far lower doses humans may get. Third, the cancer potency used in the calculation of human risk in this risk analysis is not the maximum likelihood potency value, but the upper limit value of the 95-percent statistical confidence interval.

Mutagenicity Assays

This section describes the use of the results of mutagenicity assays to draw conclusions about the risk of a chemical causing genetic effects. Mutagenicity assays are used to determine the ability of a chemical to cause physical changes (mutations) in the basic genetic material (DNA) of germ cells or somatic cells. Germ cell genetic defects could possibly lead to the passing of defective genetic instructions to offspring. The offspring may develop diseases or malformations or may be predisposed to diseases because of those inherited defects. Somatic cell genetic defects are believed to play a role in the development of certain diseases, particularly cancer.

Genetic diseases and abnormal phenotypes (for example, congenital anomalies) are produced in humans as a consequence of genetic errors occuring at the gene or chromosome levels (McKusick, 1983; Denniston, 1982). Most humans affected by genetic disease inherited their disease or predisposition for the disease as a pre-existing genetic error (Matsunaga, 1982; Carter, 1977). The same is probably true for congenital anomalies. A small percentage of affected individuals represent "new" mutations that were not pre-existing in the germ lines of their parents. The specific causes of these "new" mutations are unknown, but they could arise spontaneously or could be induced by natural mutagens (for example, aflatoxins, background radiation), therapeutic regimens (cancer treatment with agents such as cytoxan or Adriomycin), or from environmental or occupational exposures to mutagenic chemicals (Brusick, 1987).

To date, epidemiological studies of human populations have revealed the existence of more than two dozen human carcinogens but have failed to epidemiologically confirm an agent that could be legitimately classified as a human germ cell mutagen. Consequently, judgments of human genetic risk must be built upon evidence from nonhuman sources and extrapolated to human populations.

According to EPA's guidelines for germ cell mutagenicity risk assessment (EPA, 1986a), mutagenic endpoints of concern include point mutations (submicroscopic changes in the base sequence of DNA) and structural or numerical chromosome aberrations. Structural aberrations include deficiencies, duplications, insertions, inversions, and translocations. Numerical aberrations are gains or losses of whole chromosomes. Other relevant test endpoints include DNA damage, unscheduled DNA synthesis (UDS), recombination and gene conversion, and sister chromatid exchange (SCE).

The species used in mutagenicity assays range from primitive organisms, such as the bacteria *Salmonella*, *Escherichia*, and *Streptomyces*; the mold *Aspergillus*; and the yeast *Saccharomyces*; to the fruit fly *Drosophila* and to more advanced organisms, including mammalian species. Tests may be conducted in vivo (within the body of the living organism) or in vitro (on cells cultured outside the body in a petri dish or test tube).

According to Dr. David Brusick of Hazelton Laboratories (see the list of preparers), data that might be used in germ cell mutagenicity risk assessments come from mutagenicity studies that can be categorized as mammalian germ cell tests, short-term tests, and genotoxic carcinogens. Each is briefly described below.

Mammalian germ cell tests. Mammalian model studies for germ cell alterations consist predominantly of tests on rodent models (typically mice) for transmissible effects (specific locus, heritable translocation, and selected dominant genes) and nontransmissible effects (dominant lethal chromosomal aberrations and gonadal DNA damage and repair).

Short-term tests.

- Mammalian model studies for somatic cell alterations—include many of the tests commonly used in genetic toxicology, such as chromosome analysis, micronucleus tests, tests for unscheduled DNA synthesis (UDS), and measurements of DNA adducts.

- Submammalian model studies for germ cell or somatic cell alterations—typical tests in this group are the *Drosophila* sex-linked recessive lethal assay and the *Salmonella* reverse mutation assay (Ames test).

- Mammalian cell in vitro tests—cultured mammalian cells can be screened for all classes of genetic alterations (that is, chromosome damage, gene mutation, and UDS).

Genotoxic Carcinogens. The National Research Council (NRC, 1977) states that there are two broad mechanisms by which chemicals cause cancer: by some direct chemical interaction with the DNA structures of the cell or by indirect effects on the cellular environment that increase the tumor yield without direct chemical alteration of DNA. The former are termed genotoxic carcinogens and the latter, epigenetic carcinogens.

EPA describes the use of mutagenicity tests as evidence in judging the likelihood that a chemical is a genotoxic carcinogen. According to EPA's guidelines for carcinogen risk assessment (EPA, 1986b):

> Tests for point mutations, numerical and structural chromosome aberrations, DNA damage/repair, and in vitro transformation provide supportive evidence of carcinogenicity and may give information on potential carcinogenic mechanisms. A range of tests from each of the above end points helps to characterize an agent's response spectrum.
>
> Short-term in vivo and in vitro tests that can give indication of initiation and promotion activity may also provide supportive evidence for carcinogenicity. Lack of positive results in short-term tests for genetic toxicity does not provide a basis for discounting positive results in long-term animal studies.

The methods for cancer risk analysis using animal data have been reasonably well formulated. However, in the absence of rodent cancer data or with negative rodent cancer data, positive results from *short-term tests* for *genotoxicity* have been used as justification for considering the chemicals as potential carcinogens. The rationale for such a use of short-term assays rests with the close mechanistic and correlative association between carcinogens and mutagens (Brusick, 1987; Shelby, 1988).

Estimates of cancer potency that are used to assess cancer risk are based on the results of long-term feeding studies indicating tumor induction rather than on the results of short-term mutagenicity assays. An approach that has been suggested by some experts is to develop worst case estimates of cancer risk from cancer studies regardless of whether the studies show significant evidence of increasing tumor incidence with increasing dose. This risk assessment does not adopt this approach because the accepted practice in EPA and the scientific community is to consider only those chemicals with positive tumor evidence as potential human carcinogens.

It is assumed in regard to heritable mutagenicity risk that the cancer tests are the more sensitive toxic endpoint (that is, that no chemical has been shown to be a germ cell mutagen that has not been shown to be carcinogenic at lower doses), and thus cancer bioassays would constitute the worst case estimator of risk. This argument is developed in detail in Attachment F-B of this risk assessment.

Use of Short-Term Tests to Evaluate Germ Cell Risk

Background. The published EPA guidelines cited above for using short-term test data in assessing mutagenic risk fail to provide methods for quantifying genetic risk estimates. Although the EPA guidelines do provide broad qualitative risk classifications, the guidelines are insufficient to distinguish the risk estimation between two different chemicals that may fall into the same general class. Therefore, Government agencies such as the Bureau of Land Management (BLM) and the Forest Service have no guidelines for conducting quantitative risk assessments for this type of toxicity in order to reach worst case risk estimates, which should be at least semiquantitative.

Each type of genetic toxicology test described above has its particular strengths and limitations. Knowledge of these is important in extrapolating test responses to humans. For example, there may be a tendency to use a positive response from an in vitro assay, for example, to operationally define a tested chemical as a mutagen even when the chemical cannot be shown to be mutagenic in any other test. This use of in vitro data may well be an inappropriate use of such tests. Further extension of these limited positive findings into a presumption of genetic risk is not supported by the available scientific evidence. Attachment F-B provides a detailed discussion of this topic.

Correlation of Rodent Germ Cell Tests With Short-Term Test Results. Although no chemical has been conclusively established as a human germ cell mutagen, evidence from studies showing chemical-induced mutations in human somatic cells, as well as the identification of rodent germ cell mutagens, argue that at least some "new" human mutations and their resultant pathologies are likely to be the consequence of environmental exposures to mutagenic chemicals. However, without human data, mammalian germ cell models (for example, mouse assays) will have to serve as the experimental standard upon which human risk estimates are based (Ehling, 1988). If the logic of inferring human germ cell risk from the results of rodent germ cell tests is acceptable, then one can determine the relative predictive accuracy of nongerm cell tests identified in the previous section for identification of germ cell mutagens. Three review articles have summarized the results of such an exercise (ICPEMC Committee 1, 1983; Russell et al., 1984; Bridges and Mendelsohn, 1986). The scientific evidence indicates, however, that no single nongerm cell test is sufficiently accurate to predict the effects that would be obtained from animal germ cell tests. Therefore, the use of isolated positive responses from short-term tests (nongerm cell tests in mammals, submammalian assays, or mammalian cell in vitro tests) to establish genetic risks is not supported by available data and is an inappropriate use of such data. In the absence of rodent germ cell data, a weight-of-evidence approach should be applied when using short-term test results to identify potential genetic hazard.

A Weight-of-Evidence Approach to Germ Cell Mutagenicity Risk. The next approach to the use of the abundance of nongerm cell test (that is, short-term test) results is to establish a weight-of-evidence approach for collectively evaluating the composite response from all tests conducted on a specific agent.

Several qualitative (EPA, 1986a) and quantitative (Pet Edwards et al., 1985; Brusick et al., 1986) predictive or weight-of-evidence schemes for mutagenicity data have been proposed. None of these weight-of-evidence schemes have been examined in detail for concordance with the rodent germ cell data base. However, it appears necessary to use some type of weight-of-evidence scheme to assemble and evaluate a group of short-term studies.

The weight-of-evidence discussion of the results of mutagenicity assays for the three chemical insecticides in this risk assessment deals with those assays on the basis of three broad groups of mutagenicity endpoints: (1) tests for detecting gene mutations, (2) tests for detecting chromosomal aberrations, and (3) tests for detecting primary DNA damage.

Group 1 tests include microbial assays, involving prokaryotic (bacteria) and eukaryotic microorganisms (yeasts, fungus) developed to detect reverse mutations and, to a limited extent, forward mutations. Because many mutagens are inactive before bioactivation (by metabolic activity), bacterial tests may include a bioactivation system, such as an S9-fraction, consisting of microsomal enzymes of rats' or other animals' livers to activate the mutagen. A host-mediated assay is conducted to detect mutagenic effects in microorganisms, such as bacteria, by injecting a culture into the peritoneal cavity of the host (usually mice) to allow for bioactivation of the mutagen in vivo. Other tests useful for predicting gene mutations are the fruitfly sex-linked recessive lethal test, which measures the frequency of lethal mutations; the mouse specific locus test, which detects mutagenicity in germ cells in vivo; and mammalian somatic cell assays in vitro using mouse lymphoma cells, human lymphoblasts, and Chinese hamster ovary cells to detect forward and reverse mutation.

Group 2 tests for detecting chromosomal effects include mammalian cytogenetic assays in Chinese hamster ovary cells in vitro and mice bone marrow micronucleus in vivo. The dominant lethal test in rodents, which determines lethal mutation in germ cells, and the heritable translocation test in mice, which detects the heritability of chromosomal damage, are important tests performed with live animals. Fruit flies and other insects also are used to detect heritable chromosomal effects in vivo.

Group 3 tests for the existence of DNA damage caused by mutagens are based on detection of the damage by biologic processes, such as DNA repair and recombination, which occur after DNA damage. Tests to determine such processes use bacteria, yeast, and mammalian cells in vitro, with or without metabolic activation. Unscheduled DNA synthesis, for example, is often used to indicate DNA repair in human cells in vitro. Mitotic recombination and gene conversion indicate DNA damage in yeast, and sister chromatid exchange indicates DNA damage in mouse lymphoma cells, Chinese hamster ovary cells, and human lymphocytes.

The weight-of-evidence approach used in this risk assessment is similar to that of EPA (1986a). This approach places greater emphasis on assays conducted in germ cells than in somatic cells (for detecting heritable mutations), in vivo rather than in vitro, in eukaryotes rather than prokaryotes, and in mammalian species rather than submammalian species. In vivo mammalian systems are considered to be of greater value because of their similarity to human physiology and metabolism. EPA (1986a) classifies the evidence for potential human germ-cell mutagenicity as sufficient, suggestive, or limited, depending on the results of various tests performed. For instance, positive results in even one in vivo mammalian germ-cell mutation test are considered sufficient evidence for potential human mutagenicity of a specific chemical.

Epidemiology Studies

The effects on humans of exposure to chemicals in the environment can be derived from in vivo or in vitro laboratory studies (as described above), reports of clinical observations of isolated exposed individuals (human poisoning incidents), experimental studies in humans, or from direct observations of exposed human populations. The data on humans generally fall into two categories: clinical data on individuals and epidemiological data revealing patterns of disease or death in groups of humans exposed to single agents or to a variety of substances (NRC, 1986). Thus, epidemiology studies are done to investigate the causes of disease in specified human populations by examining relationships between the incidence of particular disease types and factors associated with the disease, such as the use of particular substances in the workplace. One such association is the use of various pesticides by agricultural workers and the incidence of several types of cancer.

Studies conducted by the National Cancer Institute have found that fewer farmers die from cancer than would be expected based on the cancer death rate of the U.S. general population. However, farmers have a higher risk of developing lymphatic and blood-related cancer, including leukemia and cancer of the prostate, skin, and stomach (Blair, 1982; Blair et al., 1985; Blair and Thomas, 1979; Blair and White, 1981, 1985; Cantor, 1982; Cantor and Blair, 1984; Weininger et al., 1987).

Although no single agricultural factor has been consistently associated with increased rates of specific cancer, correlations with insecticide and herbicide use were noted in a number of studies (Blair and White, 1985; Cantor, 1982; Cantor and Blair, 1984; Cantor et al., 1985). In the United States, farmers have a much lower rate of lung cancer than the general population, primarily because of their lower smoking rate (Blair, 1982). However, a cohort study of pesticide-exposed male agricultural workers in the German Democratic Republic (Barthel, 1981) found that they had a significantly higher mortality rate from lung cancer than the general population.

In a cohort study of licensed pesticide applicators in Florida, excess deaths from leukemia and cancers of the brain and lung were observed (Blair et al., 1983). The risk of lung cancer rose with the number of years the applicators had been licensed (Blair et al., 1983). Other studies have found little or no correlation between cancer incidence and pesticide use (Blair and Thomas, 1979; Blair and White, 1981), although factors such as exposure to oncogenic animal viruses have been related to increases in certain types of cancer (Blair, 1982; Blair et al., 1985).

Principal Toxic Effects of Organophosphate and Carbamate Insecticides

This section discusses the toxic hazards of the insecticides to humans as indicated by human epidemiological and clinical studies and by studies of effects in laboratory animals. This discussion of the toxicity of carbamate and organophosphate compounds was extracted from Smith (1987), Cranmer (1986), and Murphy (1980).

Exposure to organophosphates (such as malathion and acephate) or carbamates (such as carbaryl) results in the inhibition of cholinesterase (ChE) enzyme activity, specifically, acetylcholinesterase (AChE). Acetylcholinesterase is responsible for the breakdown of acetylcholine, a neurotransmitter that permits transmission of nerve impulses across the nerve synapse. Inhibition of acetylcholinesterase results in accumulation of acetylcholine and the continual transmission of nerve impulses. The extent of inhibition of ChE caused by a given dose of insecticide is usually expressed as a percent; either a percent of normal activity or as a percent reduction compared to normal activity. The inhibition process is reversible. Organophosphates tend to inhibit ChE for longer periods than the carbamates at a specific dose level, and the effects tend to accumulate so that a sequence of low doses can produce the same effect as a single higher dose. Organophosphates exhibit a pesticide-enzyme binding reaction, which is irreversible. In contrast, the carbamalated enzyme (formed in reaction with carbamate pesticides) is destabilized through biochemical processes in the body. Carbamates are relatively rapidly reversible ChE inhibitors. Organophosphates are generally metabolized, in part, to more active ChE inhibitors, for example, malathion to malaoxon. Carbamates appear to function directly as inhibitors.

Toxic effects of ChE inhibition at low doses in humans include localized effects, such as nose bleed, blurred vision, and bronchoconstriction; and systemic effects, such as nausea, sweating, dizziness, and muscular weakness. Effects of higher doses include irregular heartbeat, elevated blood pressure, cramps, and convulsions. Inhibition up to 40 percent (40-percent reduction in activity) in laboratory animals and humans is tolerated well and may produce transitory, less severe symptoms. In general, a chemical is considered to have an effect if there is 20 percent inhibition as compared to the pretreatment value for plasma, erythrocyte, and brain ChE. Inhibition above 50 percent can lead to much more severe, prolonged symptoms of ChE inhibition. Where a fatal dose of organophosphates or carbamates has been received without emergency treatment (generally by administering the antidote atropine), death usually occurs within 24 hours.

For the organophosphates, other toxic effects, in addition to ChE inhibition, include the delayed neurotoxic effects of phosphate triesters that include nerve cell demyelination and slow, but in general reversible, weakness and flaccidity of the limbs.

Biological pesticides are subjected to tests in addition to the normal toxicity assays used for chemical agents. The microorganisms are evaluated for their infectivity in rodent species following injection into specific sites. Infectivity is an important parameter because exposure to large numbers of the biological agents is possible through spills into the eyes or by inhalation of aerosols into the respiratory tract. It is also possible that accidental ingestion of the agents may occur. The production of the biological agent from large mass cultures may also introduce toxicity concerns because of contamination of the cultures by related pathogenic strains.

Human Health Hazards

The toxicological properties of malathion, acephate, and carbaryl, as determined by laboratory toxicity studies, are presented in table F2-2 (threshold effects), table F2-3 (nonthreshold effects), and table F2-4 (mutagenicity assays).

Malathion

Studies in Humans

A 47-day feeding study in 50 humans resulted in a NOEL of 0.23 mg/kg/day, where the LEL was 0.34 mg/kg/day for plasma and erythrocyte cholinesterase inhibition (EPA, 1988b). This value is the systemic NOEL for malathion in this risk assessment and is the basis for EPA's reference dose of 0.02 mg/kg/day for malathion, where a 10-fold safety factor was used to account for the range of sensitivity within the human population. According to Mattson and Sedlak (1960, as cited in Hayes 1982b), a single oral dose of 58 mg malathion (0.84 mg/kg) did not produce any clinical effects. However, according to Paul (1960, as cited in Hayes 1982b), fatal human poisoning has been reported for doses as low as 56 mg/kg. The human skin

Table F2-2—Laboratory-determined toxicity levels for threshold effects

Insecticide	Acute oral LD_{50} in rats	Lowest systemic NOEL	Lowest reproductive and/or teratogenic NOEL
Acephate	866 mg/kg (EPA, 1984a)	5 ppm (0.25 mg/kg/day), 28-month oncogenic rat-study (EPA, 1984a)	No teratogenic effects in 2 studies with rats and rabbits; teratogenic NOEL greater than 200 mg/kg/day, highest dose tested (EPA, 1984a) Maternal NOEL = 3 mg/kg/day, rabbit teratology study (EPA, 1984a)
Carbaryl	270 mg/kg (EPA, 1984b)	10.0 mg/kg/day, 2-year rat-feeding study (EPA, 1984b)	Teratogenic NOEL = 10 mg/kg/day, rabbit teratology study (EPA, 1984b)
Malathion	370 mg/kg (NLM, 1986)	0.23 mg/kg/day, 47-day human ingestion study (Moeller and Rider, 1962)	Reproductive and fetotoxic NOEL = 500 ppm (25 mg/kg/day), three-generation rat reproduction study (DHEW, 1976)

Table F2-3—Laboratory-determined toxicity levels for nonthreshold effects

Insecticide	Cancer potency[a] (mg/kg/day)$^{-1}$	Mutagenicity assays
Acephate	0.0093	Positive in mutagenicity assays using human and mammalian cells in vitro and in vivo, and in microbial cells in vitro
		Weakly positive in microbial assays; negative results for human and mammalian cells in vitro and in vivo, and in microbial cells (EPA, 1984a)
Carbaryl	0.135[b]	Negative in an in vitro mammalian assay system (Epstein et al., 1972)
		Positive in chromosomal assays (EPA, 1984b)
Malathion	0.00376	Negative in mutagenicity assays using bacteria and yeast, insect assay for sex-linked mutations, dominant-lethal tests in mice, unscheduled DNA synthesis tests, and recombination and gene reversion tests (EPA, 1988[a])
		Positive in sister chromatid exchange test and cytogenetic tests in rats (EPA, 1988[a])

[a]Converted from animals to humans according to a body surface area scaling rule.
[b]Assuming 1 percent of ingested carbaryl is converted to N-nitrosocarbaryl in the stomach (Lijinsky and Taylor, 1976).

Table F2-4—Mutagenicity testing on the three pesticides

Mutagenicity test type[a]	Value in determining human mutagenicity[b]	Pesticide[b] Malathion	Carbaryl	Acephate
Group 1--Tests for detecting gene mutations				
A. Bacteria with and without metabolic activation	+	8(-)	2(+)[c]	4(+)1(-)
B. Eukaryotic microorganisms with and without metabolic activation	+	2(-)		
C. Insects (e.g., sex-linked recessive lethal test)	++			
D. Mammalian somatic cells in culture with and without metabolic activation	++			
E. Mouse specific locus test in vivo	++			
Group 2--Tests for detecting chromosomal aberrations				
A. Cytogenetic tests in mammals in vivo	++	1(+)		1(+)3(-)
B. Insect tests for heritable chromosomal effects in vivo	++	1(-)		
C. Dominant-lethal effects in rodents, heritable translocation tests in rodents, and in vitro cytogenetic assays in mammals	++	1(-)	1(-)	1(-)[e]
Group 3--Tests for detecting primary DNA damage				
A. DNA repair in bacteria (including differential killing of DNA repair defective strains) with and without metabolic activation	NA			
B. Unscheduled DNA repair synthesis in mammalian somatic cells in culture, with and without metabolic activation	NA	1(-)		1(+)1(-)
C. Mitotic recombination and gene conversion in yeast, with and without metabolic activation	NA	1(-)		1(+)
D. Sister-chromatid exchange in mammalian cells in culture, with and without metabolic activation	NA	1(+)		1(+)1(-)

[a]Source: FIFRA, Environmental Protection Agency: Proposed Guidelines for registering pesticides in the U.S. Hazard Evaluation: humans and domestic animals. *Federal Register* 43:37335-37403, August 22, 1978.
[b]NA = Not applicable; + = Applicable; ++ = Greater applicability.
Source: Brusick (see the list of preparers).
[c]Tests were performed on N-nitrosocarbaryl.
[d]An unspecified test regimen was reported to be positive for mitotic effects and chromosomal aberrations (EPA, 1984b).
[e]Tests were performed on methamidophos.

Note: Sources for mutagenicity data are given in the text discussions of nonthreshold effects.

appears to provide an effective barrier to skin absorption of malathion. When ^{14}C-labeled malathion was applied to the ventral forearm of 12 human volunteers, an average of between 4.5 and 8.2 percent of the total dermal dose was recovered in the urine during the first 5 days (Wester et al., 1983). A 42-day inhalation study in humans did not show any cholinesterase inhibition at the highest dose tested of 2.4 g/1,000 ft^3 (0.0848 mg/L) (EPA, 1988b).

After the aerial application of malathion to a 13,000-square-mile area in the San Francisco Bay area, the occurrence of birth defects and low birth weight was examined from data from local hospitals. This study concluded that there was no increase in the incidence of congenital anomalies or low birth weight as a result of the exposure of the population to malathion (Grether et al., 1987).

Symptoms of malathion intoxication in humans include tightness of the chest, wheezing, cyanosis, pupil constriction, aching in and behind eyes, blurred vision, tearing, runny nose, headache, and salivation following inhalation exposure; loss of appetite, nausea, vomiting, abdominal cramps, and diarrhea following oral ingestion; and sweating and localized twitching after dermal exposure. High doses through any exposure route may lead to weakness, generalized twitching, paralysis, dizziness, confusion, staggering, slurred speech, irregular or depressed heart rate, convulsions, respiratory failure, coma, and death (NLM, 1988).

A reference dose of 0.02 mg/kg/day is recommended by EPA and the World Health Organization (EPA, 1988c), based on the 7-week study in humans discussed previously. The Occupational Safety and Health Administration has promulgated a standard of 15 mg/m^3 (0.015 mg/L) air concentration as a time-weighted average (NIOSH, 1987), while a standard set forth under the Federal Mine Safety and Health Act of 1977 is 10 mg/m^3 (0.010 mg/L), also a time-weighted average (NIOSH 1987).

Neurotoxicity

The principal toxic effect observed in mammals after exposure to malathion is inhibition of acetylcholinesterase, resulting in inhibition of nerve impulse propagation. Malathion itself is only slightly inhibitory; however, its oxidative metabolite malaoxon is an active inhibitor. In a study with mice, ChE activity was depressed by malaoxon 25 times more than by malathion (DHEW, 1976). Some studies indicate that conversion of malathion to malaoxon is necessary for any significant amount of anticholinesterase activity to occur. After absorption by the intestine, skin, or lungs, malathion is transported in the blood to the liver, where it is metabolized to nonacetylcholinesterase inhibitors and to malaoxon. Malathion and malaoxon are then rapidly detoxified by hydrolysis in the liver and other organs including the brain. The rapid hydrolysis and detoxification of malathion by the esterase enzyme system in humans accounts for its low toxicity in mammals (Dobroski and Lambert, 1984; DHEW, 1976).

Malathion was negative in a delayed neurotoxicity test in hens (EPA, 1988b). According to Klaassen et al. (1986), malathion has not been shown to cause other neuropathies in any species.

Acute Toxicity

Acute oral LD_{50}'s (median lethal doses) in rats range from 370 mg/kg (NIOSH, 1987) to 1,945 mg/kg (EPA, 1988a). Other reported values are as high as 2,800 mg/kg (American Cyanamid, 1986) and 5,500 mg/kg (EPA, 1987b). In sheep, the oral LD_{50} is less than 150 mg/kg; in guinea pigs, 570 mg/kg; in calves, 80 mg/kg; in cows, 560 mg/kg; in hens, 200-400 mg/kg; and in dogs, between 430 and 600 mg/kg (NLM, 1986).

Acute dermal LD_{50} values are 4,100 mg/kg in rabbits (American Cyanamid, 1986) and 4,444 mg/kg in rats (NIOSH, 1987). Two primary dermal irritation studies in rabbits led EPA (1987a) to consider malathion a slight irritant. Three primary eye irritation studies were also reported in EPA (1987a). The first two studies showed no irritation, while the third study resulted in a mild conjunctival reaction that was reversible within 7 days. Malathion is considered to be a mild eye irritant (EPA, 1988d).

An acute inhalation LC_{50} value in laboratory animals has not been defined. Three studies determined that the LC_{50} is greater than the doses tested, which were 1.7 mg/L, 4.0 mg/L, and 5.2 mg/L (EPA, 1987a).

Subchronic Toxicity

Subchronic toxicity studies with malathion include a 32-day rat feeding study with a NOEL of 100 ppm (5 mg/kg/day) and an 8-week oral rat toxicity study with a NOEL of 500 ppm (25 mg/kg/day), which was the highest dose tested (EPA, 1988a). A 4- to 6-week rat feeding study during which males were fed 62

mg/kg/day of malathion and females were fed 68 mg/kg/day resulted in a 50-percent reduction of erythrocyte, plasma, and brain cholinesterase (Craigmill, 1981).

A 90-day dog study by Kenaga (1982, cited in Smith 1987) reported a NOEL of 100 ppm (2.5 mg/kg/day) for oral administration of malathion.

Chronic Toxicity

A 2-year rat feeding study that exposed test animals to malathion at 100, 1,000, and 5,000 ppm (5, 50, and 250 mg/kg/day) resulted in decreased brain, erythrocyte, and plasma ChE at 1,000 ppm (50 mg/kg/day). At 5,000 ppm (the highest dose tested), growth retardation, total inhibition of erythrocyte ChE, and a 60- to 95-percent inhibition of plasma and brain ChE was observed (DHEW, 1976). EPA (1988a) reported the NOEL as 100 ppm (5 mg/kg/day). Another 2-year rat feeding study resulted in a NOEL of 100 ppm (5 mg/kg/day) with significantly depressed body weights and brain ChE levels at 1,000 ppm (50 mg/kg/day) (EPA 1988a).

A third 2-year rat feeding study during which animals were administered malathion at 500, 1,000, 5,000, and 20,000 ppm (25, 50, 250, and 1,000 mg/kg/day) also resulted in decreased ChE activity and body weight reduction. Histological examination of tissues revealed no microscopic abnormalities (DHEW, 1976).

Reproductive/Developmental Effects

The results of a rabbit teratology study (EPA, 1988d) were used to set the reproductive/developmental toxicity reference level in this risk assessment. The NOEL was observed to be 25 mg/kg/day. At the LEL, 50 mg/kg/day, decreases in maternal body weight gain and increases in mean percent of resorptions were observed. Other studies include a two-generation reproduction study (Kalow and Manton, 1961), in which technical grade malathion was fed to Wistar rats at a dietary concentration of 4,000 ppm (240 mg/kg/day). Male and female rats were bred after 10 weeks. Survival of the progeny after birth was found to be reduced, and the surviving offspring showed growth retardation. A single intraperitoneal injection of 600 or 900 mg/kg body weight did not result in any reproductive or developmental effects in pregnant Sherman rats (EPA, 1988b). Technical malathion was administered to rats by gastric intubation during gestation. No teratogenic effects were observed at 300 mg/kg, the highest dose tested (Khera et al., 1978).

Carcinogenicity

The oncogenic potential of malathion and its metabolite malaoxon have been evaluated based on three bioassays that EPA reviewed. An 80-week bioassay of mice and rats exposed to malathion at 4,700 and 8,000 ppm did not result in evidence of increased tumor incidence (National Cancer Institute, 1978). EPA (1988d) questioned the negative conclusion with respect to mice based on study design flaws and questionable liver findings. A second bioassay during which rats were administered 2,000 or 4,000 ppm (50 or 100 mg/kg/day) for 103 weeks did not result in evidence of carcinogenicity (NCI, 1979a). A third bioassay of the metabolite malaoxon in which F344 rats and B6C3F1 mice were administered 500 or 1,000 ppm for 103 weeks also revealed no evidence of oncogenicity (NCI, 1979b).

A review by the National Toxicology Program (NTP) reevaluated these studies on the carcinogenicity of malathion and its metabolite malaoxon (Huff et al., 1985).

The review confirmed the original conclusion of the National Cancer Institute that malathion was noncarcinogenic. However, NTP concluded that there was equivocal evidence of carcinogenicity for male and female F344 rats for malaoxon because of C-cell neoplasms of the thyroid gland. Both EPA and NTP concluded that malaoxon was not carcinogenic in mice under the conditions of this study. EPA is requiring an additional F344 rat study using malaoxon to clarify the findings of this study. Consequently, theoretical lifetime cancer risks were calculated for malathion to estimate the maximum possible risk of cancer. A cancer potency estimate of 0.00376 $(mg/kg/day)^{-1}$ was calculated, based on use of the linearized multistage model and tumor data reported for the NCI malathion mouse study by the California Department of Health Services (1980).

Mutagenicity

EPA (1988d) is requiring further studies before determining the mutagenic potential of malathion. The available data indicate that malathion does not cause gene mutations but may be a weak inducer of chromosomal breakage. A cytogenetic study (Krause et al., 1976) in rats that EPA reviewed (1988a) showed that administration of 20 mg/kg/day on the 4th through 23rd days of life caused a slight reduction of

spermatogenetic cells and Leydig cells. The authors assumed that testosterone synthesis is reduced, followed by damage to spermatogenetic cells. They also stated that all parameters had returned to normal by the 50th day of life. According to the International Agency for Research on Cancer (1983), malathion was negative for mutagenicity in most studies of bacteria, including the Ames gene mutation assay and in two studies using yeast. It was negative in a *Drosophila melanogaster* assay for sex-lined lethal mutations. Malathion increased sister chromatid exchange frequency in cultured mammalian cells and in mice treated in vivo. Dominant lethal tests in mice and a test for unscheduled DNA synthesis were negative. Recombination and reversion assays reviewed by EPA (1988a) were both negative.

Carbaryl

Studies in Humans

Acute and subchronic human exposure to carbaryl has been documented in poisoning reports, worker exposure studies, and volunteer ingestion studies. Ingestion of 2.8 mg/kg of carbaryl (Sevin® formulation) resulted in epigastric pain, sweating, fatigue, and vomiting. These effects were relieved by the administration of the antidote atropine sulfate (Harry, 1977).

Ingestion of carbaryl at dose levels of 0.25, 0.5, 1.0, and 2.0 mg/kg by 10 volunteer subjects resulted in nausea and vomiting in one subject at the highest dose tested, but no toxic effects were observed at the other dose levels (Harry, 1977). Ingestion of a single dose of carbaryl at dosage levels of 0.5, 1.0, and 2.0 mg/kg by two men per dosage level revealed no subjective or objective effects (Wills, 1968, as cited in Cranmer, 1986).

Oral doses of 0.06 mg/kg/day and 0.13 mg/kg/day were administered to six men per dose for 6 weeks in a study conducted by Wills et al. (1968, as cited in Cranmer, 1986). At the 0.06 mg/kg/day level, no abnormalities in electroencephalogram readings, plasma or erythrocyte cholinesterase levels, clinical hematology evaluations, or urine chemistry were observed. At the 0.13 mg/kg/day level, the only observed effect was a slight yet reversible depression in reabsorption of amino acids in the kidney. However, EPA (1984c) did not use the NOEL from this study to derive the reference dose because the results were limited to only a few individuals per dose (all male), and the study was conducted for only a short period of time.

Dermal application of carbaryl (5 percent Sevin® 85W) to 10 human test subjects resulted in depressed erythrocyte cholinesterase levels after 24 hours; however, 5 days after exposure, the cholinesterase levels returned to normal (Harry, 1977).

Whorton et al. (1979, as cited in Cranmer, 1986) examined semen samples from carbaryl production workers with at least 1 year of carbaryl exposure to mean air concentrations of 0.44 to 4.9 mg/m^3. The study concluded that there was no obvious depression of the sperm count or infertility in the exposed men compared to a control group of men who had not been previously exposed to carbaryl.

EPA's Office of Drinking Water (EPA, 1988e) has set health advisories for carbaryl concentration in water ingested by humans. The 1-day, 10-day, and longer-term health advisories recommend that drinking water concentrations do not exceed 1.0 mg/L, based on toxicity estimates for a 10-kg child. The lifetime health advisory level is 3.5 mg/L, based on calculations for a 70-kg adult. EPA's reference dose for carbaryl is 0.1 mg/kg/day (EPA, 1988c). The National Academy of Sciences has set an acceptable daily intake level of 0.082 mg/kg/day (EPA, 1988e).

Acute Toxicity

Based on the acute oral LD_{50} for rats of 270 mg/kg, carbaryl can be classified as a moderately toxic insecticide (EPA, 1984b). The acute oral LD_{50} for dogs was reported to be less than 500 mg/kg; for monkeys, it was found to be more than 1,000 mg/kg (EPA, 1984b). The acute dermal LD_{50} for rats was reported to be more than 4,000 mg/kg and more than 5,000 mg/kg for rabbits (EPA, 1984b).

An acute oral LD_{50} rat study reported significant depression of plasma, erythrocyte, and brain cholinesterase in the surviving test animals. An acute oral cholinesterase inhibition study resulted in depression of the erythrocyte cholinesterase level in rats after administration of carbaryl (in propylene glycol) at a dose of 12.5 mg/kg after 1 and 4 hours (EPA, 1984b). A 7-day rat cholinesterase inhibition study reported a NOEL of 10 mg/kg, with decreased levels of erythrocyte cholinesterase at the lowest-observed-adverse-effect level (LOAEL) of 50 mg/kg (EPA, 1984b).

In addition to evaluations for cholinesterase inhibition, a variety of test species have been tested for transitory neurotoxic effects (weakness, incoordination). The subcutaneous administration of carbaryl to hens at the dose level of 2,000 mg/kg did not induce demyelination (EPA, 1984b).

Subchronic Toxicity

The administration of 150 and 300 mg/kg of carbaryl daily for 8 and 12 weeks did not result in skeletal muscle lesions that could be attributed to delayed neurotoxicity (EPA, 1984b). Upon the histopathological evaluation of tissue sample reports from the above-mentioned studies, EPA concluded that carbaryl does not pose a neurological hazard (EPA, 1984c).

Chronic Toxicity

A 2-year rat feeding study reported a systemic NOEL of 200 ppm (10 mg/kg/day), which is the systemic NOEL for carbaryl used in this risk assessment. At the highest dose level of 400 ppm (20 mg/kg/day), morphological changes characterized by cloudy swelling were observed within tubules of the kidney and hepatic cords of the liver (EPA, 1984b). No neoplastic changes were observed.

A 1-year dog feeding study resulted in morphological changes in the kidneys of test animals but no apparent decrease in cholinesterase levels. The cholinesterase NOEL was reported to be greater than 7.2 mg/kg (highest dose tested) (EPA, 1984b). A systemic NOEL of 1.8 mg/kg and a LOAEL of 7.2 mg/kg were reported, based on diffuse cloudy swelling or vacuolization of kidney cells (EPA, 1984b). Similar histological effects have been observed in the kidneys of rats and monkeys after exposure to carbaryl (Wills et al., 1968). The results of this study were not used to set the systemic NOEL in this risk assessment because of significant differences in metabolism of carbaryl between dogs and other mammals.

Reproductive and Developmental Toxicity

A rabbit teratology study (EPA, 1984b) resulted in a NOEL of 10 mg/kg, where cleft palate and skeletal abnormalities were observed at the LEL of 30 mg/kg. A study (Murray et al., 1979) was conducted to evaluate the teratogenic potential of carbaryl administered by gavage or in the diet to mice and rabbits during gestation days 6 to 15 and days 6 to 18, respectively. Dietary administration to mice resulted in no teratogenic effects. A teratogenic NOEL for mice greater than 1,166 mg/kg/day (only dose tested) was reported for dietary exposure. Fetotoxic effects in mice, characterized by decreased weight gain and reduced embryo development, were observed at the dietary level of 1,166 mg/kg/day. A maternal NOEL less than 1,166 mg/kg/day was reported, based on decreased weight gain. In the gavage study, a teratogenic NOEL greater than 150 mg/kg/day (highest dose tested) was reported, and decreased weight gain and cholinesterase inhibition were reported as maternal toxic effects at 150 mg/kg/day. Administration of carbaryl by gavage to rabbits resulted in the establishment of a teratogenic NOEL of 150 mg/kg/day, based on the occurrence of omphalocele (hernia of the navel). A dose of 200 mg/kg was reported as maternally toxic, and 150 mg/kg was reported as mildly maternally toxic when administered to rabbits by gavage.

A teratology study using guinea pigs, rabbits, and hamsters resulted in teratogenic effects in guinea pigs but no apparent malformations in hamsters and rabbits. Exposure of hamsters to carbaryl at levels of 125 to 250 mg/kg and rabbits at 50 to 200 mg/kg produced no teratogenic effects. In a study reported by EPA (1988e), teratogenic bone defects were observed in guinea pigs at the dietary dose level of 300 mg/kg, although another teratology study that exposed guinea pigs to the same dose level produced no teratogenic effects (Weil et al., 1973).

A teratology study that exposed rats to dietary doses of up to 500 mg/kg/day of carbaryl did not result in teratogenic effects. Decreased weight gain was reported as a fetal toxic and as a maternal toxic effect at 500 mg/kg/day (Weil et al., 1972).

A three-generation reproduction study during which rats were exposed daily to carbaryl at 10 mg/kg/day did not significantly affect fertility, gestation, lactation, or viability of pups (Weil et al., 1972). A second three-generation rat reproduction study established a reproductive NOEL of 200 mg/kg (highest dose tested) when carbaryl was administered by gavage (Weil et al., 1973).

A teratology study during which beagle dogs were exposed to 3.125, 6.25, 12.5, 25, and 50 mg/kg of carbaryl throughout the gestation period resulted in a teratogenic NOEL of 3.125 mg/kg. Defects seen at the higher doses included abdominal fissures, failure of skeletal formation, absence of tail formation, and presence of extra toes (Smalley et al., 1968). This teratology study was classified by EPA as supplemental because it did

not meet current scientific standards. During the exposure periods, the number of animals treated was insufficient, the condition of the females was not adequately monitored, and the maternal and fetal blood levels were not adequately monitored in the treatment groups. According to EPA, "the extremely high doses of carbaryl used to elicit effects in the developing organism, coupled with the positive correlation of maternal and fetal toxicity in the multiple species tested (the dog being the possible exception), do not indicate that carbaryl constitutes a potential human teratogenic or reproductive hazard under proper environmental usage" (EPA, 1984c).

Carcinogenicity

Despite speculation that carbaryl could combine with nitrite compounds to form a carcinogen under acidic conditions similar to those in the human stomach, most studies examining carbaryl's carcinogenic potential have been negative. A preliminary report by the Carcinogen Assessment Group concluded that there was no significant increase in the incidence of tumor induction among treated animals relative to control animals (EPA, 1984b). The review of 10 chronic toxicity studies and the absence of significant tumor incidence at 400 ppm in rats and mice has provided sufficient evidence for EPA to conclude "that carbaryl is not oncogenic in experimental animals" (EPA, 1984c). Results of most of those studies are presented in the following discussion.

A 2-year rat oncogenicity feeding study was negative for carcinogenic effects at 400 ppm (20 mg/kg/day) (the highest dose tested) (EPA, 1984b). A mouse oncogenicity study during which carbaryl was given either orally at 4.64 mg/kg for 5 weeks, at 14 ppm (2.1 mg/kg/day) for 72 weeks, or administered under the skin in a single dose of 100 mg/kg did not induce cancer in test animals (EPA, 1984b). Another 2-year mouse oncogenicity study was negative at the dietary level of 400 ppm (60 mg/kg/day) (EPA, 1984b). An intraperitoneal oncogenicity study during which mice were administered carbaryl at a dose level of 60 mg/kg/week for 2 years produced no oncogenic effects in test animals (EPA, 1984b). The injection under the skin of 10 milligrams of carbaryl per week in mice for a 20-week test period was negative for oncogenic effects (EPA, 1984b). The dermal application of a 57-percent water dilution of carbaryl to mice for 30 months resulted in no oncogenic effects (EPA, 1984b).

EPA has stated that the following two studies are supplementary: a 22-month rat feeding study at the dose level of 30 mg/kg (highest dose tested) resulted in the induction of malignant tumors in 4 of 12 surviving test animals (EPA, 1984b). Oncogenic effects also were observed after the subcutaneous administration of 20 milligrams of carbaryl to 48 rats; tumors formed in 2 of 10 surviving test animals. However, no significant increase in tumor incidence in treated groups relative to controls was found by the Carcinogen Assessment Group of the Environmental Protection Agency (EPA, 1984b).

Mutagenicity

A dominant lethal rat mutation assay indicated that carbaryl was nonmutagenic at the dietary exposure level of 200 mg/kg (highest dose tested) (Epstein et al., 1972). However, chromosomal assays resulted in the induction of mitotic effects and chromosomal aberrations (EPA, 1984b). A bacterial assay characterized N-nitrosocarbaryl as a potent mutagen because of the positive mutagenic response of carbaryl in two bacterial systems (*Escherichia coli* and *Haemophilus influenzae*) (Elespuru et al., 1974). The Reproductive Effects Assessment Group of the Environmental Protection Agency has concluded that data from mutagenicity studies indicate that carbaryl does not act as a potent mutagen and can be classified as a weak mutagen (EPA, 1984c). EPA has concluded that carbaryl does not pose a mutagenic risk because only weak mutagenic responses have been measured and there is no evidence demonstrating the ability of carbaryl to reach germinal tissue, hence germ cells should not be affected (EPA, 1984c).

N-nitrosocarbaryl Formation

Under acidic conditions similar to those found in the human stomach, carbaryl has been nitrosated in the laboratory to the reaction product N-nitrosocarbaryl (Eisenbrand et al., 1975). N-nitrosocarbaryl formation optimally occurs at a pH of 1.0. The pH of the human stomach increases to about 7.0 after a meal and then returns to the normal range of 1 to 2 within minutes (Cranmer, 1986). Very little N-nitrosocarbaryl formation occurs above the pH of 2.0 (Rickard et al., 1982). Elespuru et al. (1974) found that the combination of sodium nitrite (a food additive) with carbaryl in acid solution results in the formation of nitrosocarbaryl. It is thought that human exposure to N-nitrosocarbaryl could occur from the reaction of carbaryl residues (in food) with sodium nitrite (in saliva or food) in the acidic conditions of the stomach.

N-nitrosocarbaryl has been characterized as a mutagen and a carcinogen based on positive laboratory studies (Eisenbrand et al., 1976; Elespuru and Lijinsky, 1973). A rat oncogenicity study resulted in the induction of malignant tumors at the injection site in 14 of 16 test animals after exposure to a dose level of N-nitrosocarbaryl at 1,000 mg/kg (Eisenbrand et al., 1975). Rats that were administered N-nitrosocarbaryl by gavage developed a high incidence of stomach tumors (invasive squamous carcinomas) (Lijinsky and Taylor, 1976). A rat feeding study also resulted in the formation of stomach tumors (Lijinsky and Schmahl, 1978).

N-nitrosocarbaryl appears to be a much less effective inducer of mouse skin tumors than other methylating agents such as nitrosomethylurea. Dermal application of N-nitrosocarbaryl (25 microliters of a 0.04-moles-per-liter solution) to the shaved skin of 20 mice led to the induction of skin tumors at the site of application in 8 of the test animals, but only after repeated dermal applications (twice per week for 50 weeks) to shaved skin. These tumors appeared in 1 of 20 animals at week 60, and in 8 of 20 animals by week 90 (Lijinsky and Winter, 1981). This indicates that N-nitrosocarbaryl could cause cancer in the stomach or on the skin if it could form in the environment as a result of carbaryl applications. However, the literature shows that N-nitrosocarbaryl can form only under conditions similar to those found in the human stomach—not in the air or on the skin. Thus, cancer risk from N-nitrosocarbaryl is considered only for oral exposure to the public, using a calculated cancer potency value of 0.135 $(mg/kg/day)^{-1}$.

Acephate

Acute Toxicity

Based on an acute oral LD_{50} in rats ranging from 866 mg/kg (females) to 945 mg/kg (males), acephate can be classified as a slightly toxic insecticide (EPA, 1984a). An acute delayed neurotoxicity study did not produce leg paralysis in hens exposed to 785 mg/kg/day (route not specified), which was the only dose tested (EPA, 1984a). The acute dermal LD_{50} for rabbits was reported to be greater than 10,000 mg/kg (EPA, 1984a).

The acute dermal LD_{50} for rabbits exposed to the 75-percent spray formulation of acephate was greater than 10,250 mg/kg, the highest dose tested (EPA, 1984a). An acute inhalation study in rats resulted in an LC_{50} of greater than 61.7 mg/L/4 hour (only dose tested) for the Orthene® Specialty Concentrate formulation of acephate (EPA, 1984a).

Acute laboratory testing conducted to evaluate the toxicity of the acephate impurity methylthioacetate (MTA) has demonstrated a potential hazard to the optic tracts and pituitary glands of mammals. An acute dermal study of rabbits exposed to dose levels of 1,500, 2,000, 2,500, and 3,000 mg/kg of MTA resulted in a nonreversible diminution or absence of the pupillary light reflex and blindness caused by optic tract and pituitary gland damage (EPA, 1985). Additional dermal exposure studies have not resulted in the visual impairment of test animals. EPA has requested further testing to determine the toxic and mutagenic potential of MTA.

Subchronic Toxicity

A 21-day rat feeding study resulted in a NOEL of less than 30 ppm (1.5 mg/kg/day); 30 ppm was the lowest dose tested and resulted in a 21-percent inhibition of erythrocyte cholinesterase during the second test week and a 15-percent inhibition during the third test week (EPA, 1984a). A 33- to 34-day oral cholinesterase study during which monkeys were exposed to acephate (2.5 mg/kg body weight) resulted in a 50-percent reduction of plasma, erythrocyte, and brain cholinesterase activities, and a 5 to 17 percent reduction in the activity of cerebrospinal cholinesterase (EPA, 1984a). A 21-day dermal rabbit study resulted in a significant decrease in erythrocyte cholinesterase at a dose level of 1.5 g/kg for 25 percent acephate (EPA, 1984a).

Chronic Toxicity

A provisional acceptable daily intake (PADI) level of 0.0025 mg/kg/day has been established for the inhibition of cholinesterase activity, based on the NOEL of 5.0 ppm (0.25 mg/kg/day) derived from a chronic (28-month) rat feeding study and using a safety factor of 100 (EPA, 1985).

A 2-year EPA-validated Industrial Bio-Test dog feeding study established a systemic NOEL greater than 100 ppm (2.5 mg/kg/day), based on the absence of toxic systemic effects; however, a cholinesterase NOEL of 30 ppm (0.75 mg/kg/day) was reported with reduced activities in erythrocyte, plasma, and brain cholinesterase observed at 100 ppm (2.5 mg/kg/day) (EPA, 1984a).

Reproductive and Developmental Toxicity

Teratogenic effects have not been induced in laboratory rats and rabbits upon maternal exposure to acephate during gestation. An EPA-validated Industrial Bio-Test rat teratology study reported a teratogenic NOEL greater than 200 mg/kg (highest dose tested) (EPA, 1984a; EPA, 1987b). A rabbit teratology study also resulted in a teratogenic NOEL greater than 10 mg/kg, the highest dose level tested; however, a maternal toxic NOEL of 3 mg/kg was reported, based on increased nasal discharge and increased incidence of spontaneous abortion (EPA, 1984a).

Carcinogenicity

Histopathological examination of tissue specimens from a 28-month rat feeding/oncogenicity study revealed no evidence of carcinogenic effects at the highest dose level of 700 ppm (35 mg/kg/day) (EPA, 1987b).

A 2-year oncogenicity study during which mice were exposed to 1,000 ppm (150 mg/kg/day) of acephate resulted in a 15.8-percent incidence of liver tumors (hepatocellular carcinomas) and a 19.7-percent incidence of excessive noncancerous cell growths (hyperplasic nodules) in females. At this dose level, differences in the liver, kidney, brain, and ovary weight values and decreased body weight gain also were observed compared to the control group. Dose-related liver and lung abnormalities were also observed (EPA, 1984a).

The occurrence of liver tumors in female mice has been classified by EPA as limited evidence of carcinogenicity upon evaluation of the following factors: liver tumors occurred only at the highest dose tested (150 mg/kg/day) with no substantial dose-related increase in malignant tumor incidence; no evidence of tumor metastasis was observed; tumors occurred only in female mice; and tumor incidence was observed only at the end of the study. In accordance with EPA guidelines for carcinogenic risk assessment (EPA, 1986b), EPA has concluded from this evidence that acephate is a weak carcinogen. Therefore, with the use of protective clothing and required label specifications, EPA believes that no unreasonable adverse effects will occur from using products containing acephate (EPA, 1985). However, a theoretical cancer risk assessment is presented in section F4 using a cancer potency value of 0.0093 $(mg/kg/day)^{-1}$.

Mutagenicity

Acephate was positive when tested in an unscheduled DNA synthesis assay in human fibroblast cells, mitotic crossing-over and gene conversion assays in yeast cells, the CHO (Chinese hamster ovary) cell cytotoxicity assay, bacterial recombination assays, bacterial reverse gene mutation assays, bacterial mitotic crossing-over assays, bacterial gene conversion assays, gene mutation assays in mammalian cells, and the sister chromatid exchange assay in CHO cells (EPA, 1984a). Weakly positive results were reported on the exposure of acephate to bacterial mutagenicity assays and the bacterial Ames assay (EPA, 1984a). Negative results were reported for the in vivo mouse micronucleus assay, the bacterial Ames assay, the dominant lethal mouse in vivo assay, the in vivo cytogenetic mouse bone marrow cell assay, sister chromatid exchange, and chromosomal aberration assays of monkeys and mice (EPA, 1984a). Both weakly positive and negative results were reported for a second unscheduled DNA synthesis assay in human fibroblast cells (EPA, 1984a).

According to EPA (1985), "The overall conclusion is that acephate has a definitive effect in a number of mutagenic assays. The in vivo assays, which were without response, are generally regarded to be of lesser activity; nonetheless, these negative effects show that acephate is not a strong mutagenic agent under in vivo conditions, while moderately mutagenic in cellular systems (prokariots [sic] and eukariots [sic])." This risk assessment assumes acephate is a weak mutagen with a risk of mutations no greater than that computed for cancer.

Methamidophos

Acephate is metabolized in mammalian systems to methamidophos, a relatively more toxic compound that is a registered insecticide itself. As much as 10 to 29 percent of applied acephate is transformed to methamidophos in other animals, plants, and environmental media (see Attachment F-A).

Studies in Humans

The lowest toxic oral dose of methamidophos reported for humans is 257 mg/kg (NIOSH, 1987). Toxic signs were observed in the peripheral nervous system, eyes, and skin. Effects similar to those reported for other organophosphates would be expected, particularly those associated with ChE inhibition.

Humans ingesting 256 mg/day for 5 days or 64 mg/day for 4 weeks exhibited no symptoms or detectable effects on plasma and erythrocyte ChE activity (NLM, 1987). In a 73-day study in humans, a NOEL of 0.1 mg/kg/day was reported based on ChE inhibition in erythrocytes after ingestion of a 1 to 4 mixture of methamidophos to acephate. For a 1 to 9 mixture of methamidophos to acephate, a NOEL of 0.2 mg/kg/day was determined (EPA, 1982a). The dose of methamidophos would be 0.02 mg/kg/day for either NOEL (1/5 of 0.1 mg/kg/day or 1/10 of 0.2 mg/kg/day).

NOEL and ADI levels were not established by EPA (1982b) because of data gaps. The Food and Drug Administration (1980) reported an ADI by FAO/WHO of 0.002 mg/kg/day.

Acute Toxicity

Based on acute oral LD_{50} values of 13 to 15.6 mg/kg in rats, methamidophos is classified as very toxic by EPA (1982a). A lower oral LD_{50} of 7.5 mg/kg for rats was reported by NIOSH (1987). As illustrated in table F2-5, which gives LD_{50} values for various mammals, methamidophos is 10 to 70 times more acutely toxic than acephate.

Methamidophos was very toxic when applied dermally to rabbits, based on an LD_{50} of 118 mg/kg (EPA, 1982a). Although methamidophos is considered a mild to moderate skin irritant, it was readily absorbed through the skin and was lethal to 55 to 67 percent of the rabbits studied.

Subchronic Toxicity

In a 90-day dog feeding study, a systemic NOEL of 0.375 mg/kg/day was established (EPA, 1982a). The lowest effect level was 0.125 mg/kg/day, based on plasma and erythrocyte ChE inhibition.

Chronic Toxicity

Two-year chronic feeding studies reported no significant effects in dogs fed 0.75 mg/kg/day and in rats fed 10 mg/kg/day (NLM, 1987).

Results of a recently reviewed 1-year dog study and a 2-year rat study showed that brain ChE inhibition, the effect of concern in these studies, was observed at 2 ppm (0.05 mg/kg/day), the lowest dose tested in both studies (EPA, 1984a).

Reproductive and Developmental Effects

Methamidophos was not embryotoxic or teratogenic to rabbits at 2.5 mg/kg, the highest dose tested (EPA, 1982a). However, maternally toxic effects were observed at all levels (0.1, 0.5, and 2.5 mg/kg), based on decreased weight gain.

Carcinogenicity

Methamidophos was not oncogenic in a rat-feeding study at 3, 10, and 30 ppm (FDA, 1980). Results of two additional studies indicate that methamidophos was not oncogenic in rats at dose levels of 2, 6, 18, and 54 ppm or in mice at dose levels of 1, 5, and 25 ppm (EPA, 1987b).

Mutagenicity

In a dominant lethal assay with mice, intraperitoneal injection of 1 and 2 mg/kg did not result in mutagenic effects. Results of in vitro studies with several strains of bacteria were also negative (FDA, 1980). Additional mutagenicity testing is required according to EPA (1987b).

Bacillus thuringiensis

The toxicological effects of *Bacillus thuringiensis* (*B.t.*) formulations are caused by several biologically active metabolic products of the bacterium. The delta-endotoxin is the basis for most commercial formulations. The insecticidal activity of the delta-endotoxin in the gut of insects occurs when the parasporal crystalline material is degraded under alkaline conditions. Two metabolic products of *B.t.*, which are known to be toxic to invertebrates and vertebrates, are the alpha-exotoxin and the beta-exotoxin. Formulations of *B.t.* that are currently used for Forest Service applications include Dipel® and Thuricide®, which do not contain either of

Table F2-5—Comparative oral toxicity of acephate (Orthene®) and methamidophos (Monitor®)

Animal tested	LD_{50} (mg/kg body weight)	
	Acephate	Methamidophos
Mouse	150-361	14
Rat, male (Sprague Dawley)	945-1,100	15.6-23.4
Rat, female (Sprague Dawley)	866	13-18.9
Chicken	568-852	27.5
Dark-eyed Junco	106	8

Source: Etter and Tissier, 1973, as cited in Lambert, 1985; Adair and Rich, 1977; Larson, 1975; Zinkl et al., 1981; Berteau and Chiles, 1978.

these metabolites. Beta-exotoxin is not synthesized by the strain (var. kurstaki) from which Forest Service formulations are derived. Although the alpha-exotoxin is denatured during the manufacturing process, there is a potential for its production by vegetative bacterial cells in infected insects (Luthy, 1980, as cited in Sassaman, 1987).

Most *B.t.* toxicity studies do not specify the toxin that was actually associated with the observed effect, nor do they specify that the observed effect was caused solely by the delta-endotoxin without interference from other toxins produced by *B.t.* Limited data are available on the specific toxicological effects of the delta-endotoxin on nontarget organisms. Data presented in the hazard analysis are primarily concerned with the potential toxic effects of the delta-endotoxin. Toxicity studies using *B.t.* that do not specify the toxic agent (that is, specific toxin) are identified as such.

The available literature is varied with regard to the units of measurement used to quantify toxicity. Toxicity studies presented in this text employed the following units of measure: number of viable spores per unit weight or unit volume, unit weight or unit volume applied per unit area, and percent active ingredient formulation.

Because of the nonspecific details of many *B.t.* toxicity studies available in the literature, particularly with regard to mammalian toxicity, it is difficult to evaluate the toxicity of *B.t.* by the standards used for other insecticides. *B.t.* formulations currently used by the Forest Service are generally nontoxic to mammals, including humans, because these formulations do not contain the alpha-exotoxin or the beta-exotoxin. Studies with *B.t.* formulations that do not contain alpha- or beta-exotoxin revealed no acute, subchronic, or chronic toxicity.

Human Health Effects

In one exposure incident, an 18-year-old farmer suffered eye irritation after accidentally splashing a suspension of Dipel® in his right eye (Samples and Buettner, 1983, as cited in Sassaman, 1987). The eye was immediately irrigated with water and treated with an unspecified antibiotic ointment. The eye remained irritated and was treated with corticosteroid ointment (an anti-inflammation agent) 3 days after exposure. An ulcer in the cornea was noted 10 days after the accident. *B.t.* was isolated from the lesion, which healed after 2 weeks of topical treatment with the antibiotic Gentamicin and 1 percent atropine. Sandoz, the manufacturer of Dipel®, responded to this incident by pointing out that the application of corticosteroid confounds the etiologic link with *B.t.* and questions the pathogenicity of the *Bacillus*. Their laboratory studies of direct application of *B.t.* to the eye resulted in no evidence of pathogenicity to the eye under properly controlled studies. In addition, production workers have made no complaints.

Fisher and Rosner (1959, as cited in Sassaman, 1987) reported the lack of chronic toxicity among workers exposed to *B.t.* during various stages of the production of pesticidal formulations. The individuals were exposed to whole fermentation broth, moist bacterial cake, effluent, and final powder (10 grams to several thousand pounds per day containing up to 15 x 10^9 viable spores per gram). The workers were free of any complaints during the 7 months of observation. Two individuals underwent comprehensive medical examinations and showed no evidence of acute or chronic toxicity. The specific formulations of *B.t.* were not specified in this report.

Acute Toxicity

No deaths were reported among mice when *B.t.* was administered orally at 0.3 and 1.5 x 10^6 spores per gram (Kimura 1970, as cited in Sassaman, 1987). The toxin in this formulation was not specificied. Hernandez and Mclean (undated, as cited in Sassaman, 1987) administered *B.t.* spores to rats in the feed for 1 day. No deaths, adverse effects on body weight gain, or abnormalities in blood counts were observed among the treated animals during a 13-day observation period. The test material in this study may have contained beta-exotoxin as a toxic agent.

No skin irritation was observed 3 days after a 20-percent suspension of Dipel® was applied to either shaved unabraded or shaved abraded skin of the rabbits (Kimura, 1980, as cited in Sassaman, 1987). Skin irritation was observed in the form of erythema and eventual dry skin and sloughing, leaving a smooth, hairless treatment area following application of Dipel® 4L to the skin of rabbits at 7.2 g/kg in an acute dermal toxicity study (Abbott, 1986, as cited in Sassaman, 1987).

No mortalities were observed among an unspecified number of mice or rats 7 days after they were exposed to an aerosol of a 20-percent suspension of Dipel® for 10 minutes (Kimura, 1970, as cited in Sassaman, 1987).

No acute eye irritation was observed in rabbits following ocular instillation of 0.1 mL of a 10-percent suspension of Dipel® (Kimura, 1970, as cited in Sassaman, 1987).

Subchronic Toxicity

In a 13-week Dipel® feeding study conducted by Olson and Kwapien (1973, as cited in Sassaman, 1987), 10 rats per group were administered 0.84 mg/kg dietary concentration for 1 week, then 840 mg/kg dietary concentration for 12 weeks (group 1); and 8.4 mg/kg dietary concentration for 1 week, then 8,400 mg/kg dietary concentration for 12 weeks (Group 2). A third group served as the untreated control group. No significant findings were observed in hematology, clinical chemistry, or urinalysis evaluations. In addition, there were no abnormal findings in the gross pathology or histopathology evaluations.

Biotrol® was administered in the diet to groups of 20 rats (10 of each sex/group) at dietary levels of 1, 1.25, 2.5, 5, and 10 percent for 49 days (Forsberg et al., 1976, as cited in Sassaman, 1987). No significant differences were observed between treated and control groups of animals. The test material may have contained beta-exotoxin as a toxic agent.

Chronic Toxicity

Administration of Biotrol® (25×10^9 spores per gram) at a 1-percent level in the diet of 25 female and 25 male rats for 2 years revealed no significant differences between control and treated groups of animals (Barnes, 1970, as cited in Sassaman, 1987).

Reproductive and Developmental Toxicity

The literature contains no data about the reproductive or teratogenic effects of *B.t.*

Carcinogenicity

The literature contains no data about the carcinogenic potential of *B.t.*

Mutagenicity

B.t. was not mutagenic in *Salmonella typhimurium* strains when they were exposed to varying concentrations (1,000 to 100,000 L/plate) of exotoxin, both with and without rat liver S-9 microsomal enzyme preparation (Cantwell et al., 1982, as cited in Sassaman, 1987). *B.t.* was also not mutagenic in *Saccharomyces cerevisiae* strains when they were treated with *B.t.* serotypes 1 and 3, and beta-exotoxin (Linnainmaa et al.,1977, as cited in Sassaman, 1987).

Human lymphocyte cultures were treated with *B.t.* serotypes 1 and 3 (Meretoja et al., 1977, as cited in Sassaman, 1987). The cultures treated with serotype 1 (containing beta-exotoxin) resulted in increased incidence of chromosomal aberrations. However, there was no increased incidence of chromosomal aberrations in the cultures treated with serotype 3, which did not contain beta-exotoxin.

Fruit flies (*Drosophila melanogaster*) were fed with *B.t.* serotypes 1 and 3 and exotoxin during the entire period of their development (Linnainmaa et al., 1977, as cited in Sassaman, 1987). All test materials were negative in nondysjunction tests. However, serotype 1 induced an increase in the frequency of sex-linked recessive lethal mutations.

Rats were treated with *B.t.* serotype 1 in drinking water for 3 months. Blood lymphocytes and bone marrow cells from the treated animals were analyzed (Meretoja et al., 1977, as cited in Sassaman, 1987) and showed that *B.t.* serotype 1 induced an increase in incidence of chromosomal aberrations in the lymphocytes, but not in the bone marrow cells of the treated animals.

Diesel Oil

Acute Toxicity

Sevin® 4-Oil is formulated with petroleum products and diluted with diesel oil. Beck et al. (1982) conducted a short-term exposure study examining the acute toxicology of 19 petroleum hydrocarbons in acute oral, acute dermal, dermal irritation, and eye irritation studies. Based on an acute oral LD_{50} of 9 mL/kg (7,380 mg/kg),

diesel oil can be classified as a very slightly toxic compound. The most marked acute toxic effect observed after the administration of diesel oil to test animals occurred during primary dermal irritation studies. A single dermal diesel oil exposure to rabbits resulted in a rating of "extremely irritating" based on a score of 6.82 (on a scale of 1 to 10), although the irritation may have been caused by additives to the diesel oil for use in internal combustion engines. Diesel oil was nonirritating in primary eye irritation studies.

Subchronic Toxicity

A 3-week dermal study of eight rabbits resulted in an average weight loss of 0.38 kg at the dose level of 4 mL/kg (3,280 mg/kg), and an average weight loss of 0.55 kg with a 67-percent mortality rate at the dose level of 8 mL/kg (6,560 mg/kg).

Reproductive and Developmental Toxicity

An inhalation teratology study in which rats were exposed to 101.8 ppm (5.09 μL/kg) or 401.5 ppm (20.075 μL/kg) of diesel fuel on days 6 through 15 of gestation did not result in any significant teratogenic effects (Mecler and Beliles, 1979).

Carcinogenicity of Petroleum Distillates

The carcinogenic potential of petroleum fuels is directly related to refinery processing methods used to obtain the petroleum product and the crude oil composition from which the fuel was derived. An evaluation of the composition of petroleum fuels has revealed that a positive correlation exists between polycyclic aromatic hydrocarbon (PAH) content and carcinogenicity in human epidemiology studies and experimental laboratory studies (Bingham et al., 1979).

Diesel oil is a complex variable mixture of hydrocarbons with a boiling point range of 170 to 370 °C and an aromatic content ranging up to 35 percent (DOE, 1983). Diesel fuel, which is usually a straight-run distillation product that boils below 650 °F and that contains few polycyclic aromatics, has not been shown to be carcinogenic. Kerosene is a straight-run petroleum distillation fraction (NLM, 1987), with a boiling point range of 175 to 325 °C and an aromatic content of 15 to 20 percent.

A 2-year oncogenic skin painting study, which was terminated after 62 weeks, during which Swiss Epley mice were exposed to 0.05 mL (41 mg) of diesel fuel products resulted in skin carcinomas in 2 of 50 animals, which was not statistically significant by chi-square analysis. The study was prematurely terminated because of the presence of extensive skin lesions in test animals (American Petroleum Institute, 1983a). Higher boiling point (greater than 700 °F) petroleum products that are subjected to additional refinement processes, such as cracking or hydrogenation, and that contain polycyclic aromatics may be carcinogenic to experimental animals (Bingham et al., 1979).

Specific substances that are known or suspected of being carcinogenic, which are contained in diesel oil and kerosene in small amounts, include benzo(a)pyrene and benzene. Benzo(a)pyrene (BaP), a potent carcinogen, is a PAH that also occurs at low levels in foods and in products of combustion, including cigarette smoke. Bioassays have indicated that the concentration of this single carcinogen can often serve as a guide in predicting the carcinogenic potency of petroleum distillates, although other substances are also known to be involved (Bingham et al., 1979). Sufficient evidence exists for the carcinogenicity of BaP in experimental animals: BaP has produced tumors in all of the nine species for which data have been reported following various methods of administration (DHHS, 1985); it has both a local and systemic carcinogenic effect. EPA has estimated the carcinogenic potency of BaP as 11.5 $(mg/kg/day)^{-1}$ (EPA, 1986c).

For benzene, another aromatic known to be present in diesel oil and kerosene, sufficient evidence exists for its carcinogenicity in experimental animals (DHHS, 1985). It also has been shown to cause leukemia in workers with chronic exposure.

EPA has estimated the carcinogenic potency of benzene as 0.0445 $(mg/kg/day)^{-1}$ (EPA, 1986d). But benzene can occur at greater concentrations (approximately 29 ppm in No. 2 fuel oil) than BaP in diesel oil. Consequently, the carcinogenic potencies of diesel oil have been estimated for this EIS based on the potencies of both benzene and BaP.

Samples of diesel oil and fuel oil have been found to have a BaP content of only 26 ppb, but No. 2 heating oil (which may be subjected to cracking, rather than straight-run distillation) can contain 600 ppb (Bingham et al., 1979). The midpoint of this concentration range (313 ppb) has been used to calculate the carcinogenic

potency of diesel oil, although most diesel fuels can be expected to have a lower BaP content. The content of benzene in diesel fuel was assumed to be 28.5 ppm, based on analysis of water extracts of No. 2 fuel oil by Anderson (1975), with corrections for solubility relationships. The resulting estimate of carcinogenic potency of diesel oil is 4.9×10^{-6} $(mg/kg/day)^{-1}$. Of this potency, 74 percent is a result of the BaP component.

A case control epidemiology study revealed an increased relative risk of developing bladder carcinoma in men who are occupationally exposed to oil or gasoline, kerosene, chemical materials, or asphalt (Mommsen and Aagard, 1984).

Petroleum products with boiling points greater than those of kerosene or diesel fuel (greater than 370 °C) that are subjected to additional refinement processes, such as cracking or hydrogenation, and that contain polycyclic aromatics may be carcinogenic to experimental animals (Bingham et al., 1979).

Mutagenicity

Diesel fuel was nonmutagenic when tested in the Ames assay and the mouse lymphoma assay; however, it was found to be clastogenic (causing chromosomal aberrations) in rat bone marrow cells (Conaway et al., 1982). Because diesel oil contains polycyclic aromatic hydrocarbons and other constituents that are known or suspected mutagens, it is considered to be a mutagen for this risk assessment.

Kerosene

Acute Toxicity

Kerosene can be classified as very slightly toxic, based on the lowest oral lethal dose of 28,000 mg/kg in rats (NLM, 1987). Toxic effects after ingestion include irritation of the mouth, throat, and stomach; nausea and vomiting; drowsiness; rapid heart beating; and shallow respiration (ITII, 1976). In primary irritation studies, jet fuel A (a type of kerosene with a boiling range of 163 °C to 282 °C) was mildly irritating to the skin and eyes of rabbits and was nonsensitizing to guinea pigs (Beck et al., 1982). Jet fuel A caused no mortalities in rats given acute dermal doses of 5,000 mg/kg (Beck et al., 1982).

The lowest intratracheal lethal dose of kerosene in rats is 800 mg/kg (NLM, 1987). Inhalation of kerosene may cause headaches, excitement, dizziness, languor, ataxia (defective control of muscles), nausea, bronchitis, anemia, and inflammation of the nerves (ITII, 1976). Intratracheal instillation of kerosene into rats caused an increase in lung weight in proportion to body weight, suggesting pulmonary congestion (Scharf et al., 1981). Scharf and colleagues also observed hyperemia (much greater than normal blood flow) of the lungs, focal bronchopneumonia, and increased total lung capacity. These changes were maximal by 24 hours after instillation and returned to normal within 2 weeks.

Results of a study in which kerosene was administered to baboons by various routes suggest that the primate brain is resistant to the direct toxic effects of kerosene (Wolfsdorf and Paed, 1976). The authors concluded that even at high dose levels, the liver and lung were able to filter out sufficient amounts of kerosene to protect the brain from damage.

Subchronic Toxicity

In a 28-day dermal toxicity study with hydrodesulfurized kerosene, rabbits showed dry, flaking, and/or cracking skin; scab formation; necrosis (localized cell death); sloughing; fissuring; thickened skin; and ulcerations at all dose levels (200, 1,000, and 2,000 mg/kg/day) (American Petroleum Institute, 1983b). At the high-dose level (2,000 mg/kg/day) rabbits exhibited treatment-related skin and liver lesions.

In a 3-week dermal toxicity study with jet fuel A, exposure to 8.0 mL/kg/day caused 75 percent mortality in rabbits (Beck et al., 1982). Treatment-related effects included anorexia, weight loss, depression, severe dermal irritation, and pale liver and kidneys.

Male rats were given subcutaneous administration of commercial kerosene at 0.5 mL/kg/day, 6 days per week for 5 weeks (Rao et al., 1984). Treatment-related effects included increased weight of the liver, spleen, and peripheral lymph nodes; increased DNA, RNA, protein, and lipid contents of the liver and spleen; lesions in the liver, spleen, thymus, kidney, adrenal, and lymph nodes; and imbalanced enzyme levels (decreased activity

of succinate dehydrogenase, glucose-6-phosphatase, magnesium-stimulated adenosine triphosphatase, and increased activity of acid phosphatase).

Rats exposed to 75 and 300 mg/m³ of kerosene mist for 14 weeks exhibited functional, morphological, and cytoenzymatic changes in the lungs and kidneys (Starek and Kaminski, 1981 and 1982). Changes in the kidney were associated with the magnitude of exposure (Starek and Kaminski, 1982). In addition, disturbances of the acid-base equilibrium in blood were noted (Starek and Kaminski, 1981).

Carcinogenicity

The carcinogenic potential of kerosene is similar to that of diesel oil because the same substances (BaP and benezene) are responsible in both cases. The discussion of kerosene's carcinogenicity is included in that of diesel oil's.

Mutagenicity

Kerosene was nonmutagenic both with and without metabolic activation in the Ames bacterial assay and the mouse lymphoma assay (Conaway et al., 1982). Kerosene also was nonmutagenic in the rat cytogenetic bone marrow assay (Conaway et al., 1982).

Ecological Hazards

Malathion

Mammalian Toxicity

Malathion is moderately toxic to mammals. The lowest oral LD_{50} for rats is 370 mg/kg.

No effects on wildlife were observed in population censuses, carcass counts, and tissue residue analysis in areas sprayed at 6.8 oz a.i./acre of malathion (McEwen et al., 1972, as cited in Dobroski and Lambert, 1984).

The discussion in the human health hazard subsection of this risk assessment provides details on the chronic toxicity, oncogenicity, teratogenicity, and mutagenicity of malathion.

Avian Toxicity

The oral LD_{50} of malathion to chickens is 150 mg/kg to 850 mg/kg (EPA, 1975). The oral LD_{50} is 167 mg/kg for pheasants and 403 mg/kg for the horned lark (Hudson et al., 1984). The LD_{50} in mallards is 1,485 mg/kg. Signs of intoxication that appeared at lethal and near-lethal doses included ataxia, walking high on toes, imbalance, hypoactivity, wing-drop, weakness, slowness, sitting, ptosis, falling with wings spread, tenesmus, salivation, swallowing, tremors, dyspnea, and convulsions (Hudson et al., 1984).

A study in Michigan found no significant adverse effects on birds and mammals in areas sprayed with malathion at 1 lb a.i./acre. Caged pheasants held in the area showed no adverse effects and no effects were observed in necropsied birds (DOI, 1963). In Texas, cotton fields were repeatedly treated with malathion at 12 oz to 16 oz a.i./acre. No effects on birds were noted in wildlife areas adjacent to the fields. Caged quail held among treated rows of cotton also showed no effects (Sinclair, 1968).

Areas in Nebraska treated with 8 oz a.i./acre of malathion showed no significant effects on birds or mammals. However, domestic turkeys that were held in cages in treated areas and allowed to feed on insects from the treated area had slightly depressed plasma ChE levels, but no external symptoms were noted (USDA, 1985).

Birds in a forested watershed that had been treated with 0.7 lb a.i./acre of malathion appeared noticeably quiet for a 2-day period after the spraying. This may have been the result of acetylcholinesterase (AChE) inhibition, which has been directly related to a decrease in physical activity. No other effects were observed (Dobroski and Lambert, 1984).

Malathion at extremely high doses has been shown to decrease brain AChE in quail and mallards (Dobroski and Lambert, 1984). Although malathion appears to reduce brain ChE and AChE levels, the minimum application rate to cause this effect has not yet been determined. Further research in this area has been suggested by the U.S. Fish and Wildlife Service (1986).

In a study that measured brain cholinesterase activity after a city-wide aerial application, malathion was shown to reduce ChE of sparrows from 6 to 12 percent compared to their respective activity levels before treatment. The application rate for this study was 140 mL/hectare (Kucera, 1987).

Effects on Avian Reproduction. Reproductive effects of malathion have been studied in chickens. Birds were exposed to increasing amounts of malathion in their feed for 29 weeks. Doses were 100 mg/lb of feed for 4 weeks, 200 mg/lb of feed for 3 weeks, and 500 mg/lb of feed for 22 weeks. Test results indicated reduced weight gains and a 25-percent mortality of test birds. Egg production was not affected (EPA, 1975). In a study with chickens, no reduction in hatchability of eggs was observed after 2 years of exposure to 2,500 ppm of malathion in feed (EPA, 1975). In another study, eggs injected with 2.5 mg each of malathion and carbaryl did not hatch (Ghassemi et al., 1981). Other studies have confirmed the reduced hatchability of chicken eggs after malathion injection (NRC, 1977).

Insect Toxicity

Effects on Honey Bees. Malathion is highly toxic to bees and can cause severe losses if bees are present at the time of treatment with this pesticide. Damage to bee populations can be considerably reduced by timing the application to avoid exposing bees to freshly applied malathion. The 48-hour LD_{50} in honey bees (*Apis mellifera* L.) is 0.709 μg per bee for exposure to malathion dust (Atkins et al., 1973, as cited in Dobroski and Lambert, 1984).

Treatments while bees are foraging in the field are usually the most hazardous. Furthermore, application over colonies in hot weather, when bees are clustering on the outside of the hives, may result in severe losses. Treatments during night and early morning, before bees begin foraging, are safest. Injury usually is not significant to colonies one-quarter of a mile or more from treatments unless the treated field is the only attractive crop in the area. The farther the colonies are from the treatment area, the less critical the treatment time. Colonies moved into the field 2 or 3 days after treatment usually escape damage (Dobroski and Lambert, 1984).

Residual action of ultra-low-volume (undiluted) application of malathion on bees exhibits four times greater toxicity than that usually encountered after dilute applications. Pesticide applications by aircraft have been shown to be more hazardous than application by ground equipment. Granular application has been shown to be the method of treatment safest for bees (Dobroski and Lambert, 1984).

Bees collecting pollen from treated areas may be killed in great numbers when walking over treated surfaces, but an equally significant danger lies with the pollen itself. Older bees (normally the worker bees) are less susceptible to malathion and may carry contaminated pollen back to the hive before they sicken and die. Young and reproductive members of the colony that eat the pollen also may die. Once in the hive, the contaminated pollen may remain toxic for months. However, if bees are removed beyond flight range from an area to be sprayed and not returned for 3 days, mortality is not significant. Most recommendations include moving the colony for a brief period or confining the bees to their hive before and shortly after spraying (Dobroski and Lambert, 1984).

Effects on Other Beneficial Insects. As a broad spectrum pesticide, there is little, if any, selectivity between the toxicity of malathion to target pests and to beneficial insects on the same plant (Dobroski and Lambert, 1984).

Malathion is toxic to beneficial parasites and predators such as ladybird beetles and parasitic wasps. A study of beneficial insect populations was conducted over 4 years where repeated applications of 12 and 16 ounces of active ingredient malathion were made annually. The applications resulted in an adverse effect on ladybird beetles, scymnus beetles, hooded beetles, softwinged flower beetles, and lace-winged beetles immediately after the application. However, the researchers found no major differences in the spring populations of beneficial insects (Huddleston et al., 1968).

Investigations of malathion application suggest that certain insect orders are more susceptible than others. Observations of the effects of low-volume aerial application of malathion for mosquito control showed that the insect orders Homoptera (cicadas, leafhoppers, and the like) and Hemiptera (the true bugs) declined during the treatment period; whereas other insect orders, including Diptera (the flies), with the exception of family Culicidae (the mosquitoes), were not affected. Many insects in the order Hymenoptera (bees, wasps, ants, and the like) seemed to be especially susceptible to malathion (Dobroski and Lambert, 1984).

Another study of the effects of malathion applications (8 oz a.i) to nontarget leafhoppers indicated only one of five monitored species failed to recover to control area population levels within 2 weeks after treatment. One species, *Scaphytopius acutus* (Say), was suppressed from one growing season to the next.

Reductions in beneficial predator wasps and parasites are only temporary because of the short-lived residues of malathion (Manser and Bennet, 1963, as cited in Dobroski and Lambert, 1984).

Aquatic Species Toxicity

The acute toxicity of malathion for a number of aquatic organisms is shown in table F2-6.

Fish. Fish sensitivity to malathion depends on species, water quality, temperature, and exposure times (EPA, 1975). In general, malathion appears to have a moderate level of toxicity to some species of fish. Species such as carp may tolerate this insecticide at the normal rate of application in mosquito control, whereas others, such as striped bass and mosquito fish, may suffer moderate to high mortality.

Malathion applied for grasshopper control in Montana slightly reduced brain cholinesterase levels between prespray and postspray samples of cutthroat and eastern brook trout. No effect was observed on the live caged fish as a result of the 8-ounce malathion application (DOI, 1967).

Two farm ponds repeatedly treated with 16 ounces (1.16 pounds) per acre of malathion were studied in a cotton-growing area of Texas. No mortality was reported for resident largemouth bass and other game fish and forage species (Fischer, 1966).

Results from an investigation of the direct effects of a wide area application of malathion on fish indicated that, when aerially applied at the ultra-low-volume rate, malathion did not result in direct mortality of captive bluegill (*Lepomis macrochirus*) and fin fish populations native to the stream running through the study area (Dobroski and Lambert, 1984).

An investigation of the relative susceptibility to insecticides of representatives in the families Ictaluridae (catfish), Cyprinidae (minnows), Centrarchidae (sunfish and bass), Percidae (perch), and Salmonidae (salmon, trout, and chars) demonstrated that members of the families Ictaluridae and Cyprinidae were considerably more tolerant of malathion than species in the other families studied.

Aquatic Invertebrates. The aquatic invertebrates most acutely sensitive to malathion are scuds (amphipods), stoneflies, and caddisflies (see laboratory test results in table F2-6). Field studies support the finding that scuds are sensitive to malathion. Study sites in Wyoming treated with 8 ounces of malathion per acre indicated that the amphipod *Hyalella azteca* (saussure) was reduced to nearly zero and showed no recovery 1 year later (Pfadt et al., 1985).

However, some studies have shown differences between laboratory and field effects on aquatic arthropods. Shrimp and *Daphnia* have been shown to be very sensitive to malathion in the laboratory, but ground applications at typical mosquito control levels resulted in no significant effects on crustacea, including shrimp and plankton species (Dobroski and Lambert, 1984).

Malathion was not found to be toxic to red crawfish at concentrations that were effective in large-scale control of the target pests (Muncy and Oliver, 1963, as cited in Dobroski and Lambert, 1984).

Aerial applications of malathion have been implicated in population reductions of the insect families Chironomidae (midges), Ceratopogonidae (biting midges), Sciaridae (gnats), and Empidae (dance flies) and the orders Collembola (springtails), Plecoptera (stoneflies), and Ephemeroptera (mayflies). However, reductions of aquatic populations appear to be short lived, and rapid recovery is likely (Dobroski and Lambert, 1984).

Aquatic Plants. No adverse effects of malathion on aquatic plants have been reported. Algae metabolize malathion quite rapidly, and the degradation products are not harmful (Mulla and Mian, 1981). Field studies of ULV aerosol applications of malathion to a salt marsh resulted in no adverse effects to aquatic plants (Tagatz et al., 1974, as cited in Mulla and Mian, 1981).

Table F2-6—Acute toxicity of malathion to aquatic organisms[a]

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (µg/L) (95% confidence interval)
Fish			
Rainbow trout	12	1.4	200 260-240
Cutthroat trout	12	1.0	280 270-310
Brown trout	12	1.1	101 84-115
Lake trout	12	0.3	76 47-123
Channel catfish	18	1.5	8,970 6,780-12,000
Black bullhead	18	1.2	12,900 10,700-15,600
Yellow perch	18	1.4	263 205-338
Walleye	18	1.8	64 59-70
Largemouth bass	18	0.9	285 254-320
Bluegill	18	1.5	103 87-122
Green sunfish	18	1.1	175 134-228
Redear sunfish	24	3.2	62 58-67
Fathead minnow	18	0.9	8,650 6,450-11,500
Carp	18	0.6	6,590 4,920-8,820
Goldfish	18	0.9	10,700 8,340-13,800
Invertebrates			
Simocephalus (daphnid)	15	First instar	3.5[b] 2.6-4.8
Daphnia magna (daphnid)	15	First instar	1.0[b] 0.7-1.4
Daphnia pulex (daphnid)	15	First instar	1.8[b] 1.4-2.4
Cypridopsis (seed shrimp)	21	Mature	47[b] 32-69
Asellus (sowbug)	21	Mature	3,000 1,500-8,500
Gammarus fasciatus (scud)	21	Mature	0.76 0.63-0.92

Table F2-6 (continued)—Acute toxicity of malathion to aquatic organisms[a]

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (µg/L) (95% confidence interval)
Invertebrates (continued)			
Orconectes (crayfish)	15	Early Instar	180[c] 140-230
Palaemonetes (grass shrimp)	21	Mature	90[c] 67-120
Pteronarcys (stonefly)	15	Second Year class	10 7.0-13
Pteronarcella (stonefly)	15	Naiad	1.1 0.8-1.5
Claassenia (stonefly)	15	Second Year class	2.8 1.4-4.3
Isoperla (stonefly)	15	First Year class	0.69 0.20-2.4
Lestes (damselfly)	15	Juvenile	10 6.5-15
Hydropsyche (caddisfly)	15	Juvenile	5.0 2.9-8.6
Limnephilus (caddisfly)	15	Juvenile	1.3 0.8-2.0
Atherix (snipe fly)	15	Juvenile	385 246-602
Amphibians			
Woodhouse's toad (*Bufo woodhousii*)	15.5	--	420[d]

[a]Technical material, 95 percent.
[b]48-hour EC_{50}.
[c]Tested in hardwater (162-272 ppm $CaCO_3$).
[d]Mulla and Mian, 1981.

Sources: Johnson and Finley, 1980; Mulla and Mian, 1981.

Carbaryl

Mammalian Toxicity

Carbaryl is considered moderately toxic to mammals. The acute oral LD_{50} of carbaryl ranges from 150 mg/kg to 710 mg/kg for mammalian species (Ghassemi et al., 1981; Hudson et al., 1984; NLM, 1986). Carbaryl is used on cattle and pets to control insect pests. Acute oral LD_{50}'s for mammals and birds are shown in table F2-7.

Several studies have examined the effects of carbaryl on wild populations of small mammals with varying results, according to application rates. The proposed rate for this program is 1.0 lb a.i./acre (16 oz a.i./acre) of carbaryl, which is lower than any of the reported studies. In Canada, no changes were observed in small mammal populations 2 months after spraying forested areas with carbaryl for spruce budworm control (Buckner et al., 1973, as cited in Ghassemi et al., 1981). A study of an area in New York treated with 1.25 lb a.i./acre of carbaryl reported no adverse effects on small mammals or deer (Connor, 1960, as cited in Dobroski, 1985).

Denisova (1973, as cited in Ghassemi et al., 1981) reported a decrease in mole and rodent populations in forests treated with carbaryl at a high rate (4.46 lb per acre). No recovery of populations was reported within 2 years. Tissue residues of carbaryl in males were 5 mg/kg in reproductive organs, 3 mg/kg in liver, and 1.5 mg/kg in muscle.

Barrett (1968) reported a decline in cotton rat populations, an increase in house mouse populations, and no change in old field mouse populations following treatment of a millet field at 2 1b a.i./acre of carbaryl. Carbaryl residues in millet were 35 ppm. There was a 4-week delay in the reproductive cycle of the cotton rat. Laboratory studies by Barret supported these findings. Doses of 1.1 mg/adult/day (similar to those in the field study) resulted in a greater than 50-percent decline in the number of female cotton rats giving birth and in the total number of litters. At the same dose, reproduction in the house mouse was not affected.

Avian Toxicity

Carbaryl is considered slightly toxic to birds. It is used on poultry to control insect pests. The acute oral LD_{50} ranges from 780 mg/kg to more than 2,500 mg/kg for avian species (Ghassemi et al., 1981; Hudson et al., 1984; NLM, 1986). The LD_{50} is greater than 2,564 mg/kg for mallards. Toxic symptoms observed in birds at lethal or near-lethal doses include inactivity, ataxia, regurgitation, weakness, fluffed feathers, salivation, slowness, lethargy, tachypnea, tremors, tetany, paralysis, coma, and convulsions (Hudson et al., 1984).

Results of carbaryl studies on birds vary. A number of studies have reported no effects on bird populations in areas treated with carbaryl. Several studies have reported decreased levels of ChE activity. One study has reported significant declines in bird populations, possibly resulting from reduced food supplies.

The following studies showed no adverse effects at application rates equal to or greater than the rate proposed for the Forest Service's spruce budworm control program (1.0 lb a.i./acre): In New York, an area was treated with carbaryl at a rate of 1.25 lb a.i./acre. No effects were observed on behavior, reproduction, or rearing of young in 49 species of birds (Connor, 1960, as cited in Dobroski, 1985). Following carbaryl spraying, no significant effects were observed on nesting success, total number of breeding birds, mortality rates, or brain ChE levels (Zinkl et al., 1977, as cited in Dobrowski, 1985). Richmond et al. (1979, as cited in Lambert, 1985) reported a similar lack of adverse effects to birds in Oregon after applications of 2 lb a.i./acre of carbaryl. No adverse effects were reported in birds in Colorado at a rate of 1 lb a.i./acre (McEwen et al., 1962, as cited in Dobroski, 1985). Bart (1979) reported no changes in bird populations or song frequency in forest plots treated at 1 lb and 5 lb of carbaryl per acre. No changes in songbird populations occurred up to 3 weeks after spraying Canadian spruce forests as 1 lb carbaryl per acre (Buckner et al., 1973, as cited in Ghassemi et al., 1981).

A decrease of brain cholinesterase in forest birds in Montana was measured after applications of carbaryl at 1 lb a.i./acre (Zinkl et al., 1977, as cited in Dobroski, 1985). The authors suggested that ChE depression to the levels observed may reduce a bird's ability to avoid predators and to obtain food. Another study reported no decrease in ChE levels in birds in Maine forests treated at 0.31 lb and 0.69 1b per acre (Gramlich, 1979). Knowledge is lacking regarding the minimum application rate of carbaryl that causes ChE depression. Further research is needed in this area to more accurately assess impacts on wildlife.

Table F2-7—Acute oral toxicity of carbaryl in mammalian, avian, and insect species

Animal tested	LD_{50} (mg/kg)[a]
Mammals	
Cat	150
Rat	250
Mouse	275
Mule deer[b]	200 to 400
Rabbit	710
Birds	
Mallard	>2,564
Pheasant	>2,000
Rock dove	1,000-3,000
Chukar	(1,498-2,378)[c]
Japanese quail	2,290 (1,740-3,020)[c]
Sharp-tailed grouse	780-1,700
Canada goose	1,790 (1,480-2,180)[c]
Insect	
Adult Bee	10(1 μg/bee)

[a]Numbers in parentheses are the 95-percent confidence intervals.
[b]Female, age = 11 months.
[c]50 percent carbaryl.

Sources: NLM, 1986; Hudson et al., 1984; Ghassemi et al., 1981; Stevenson, 1970, as cited in Dobroski, 1985.

Forested areas in New Jersey treated in June for gypsy moth control with carbaryl at 1 lb/acre resulted in a 55-percent decrease in bird populations within 2 weeks after spraying and showed no recovery during 6 more weeks of monitoring or in the following year during June and July (Moulding, 1972). The unsprayed plot showed no significant changes. It was noted that canopy species were more affected than ground feeders. The author suggested the following possible explanations for the overall decline of birds: opportunistic feeding outside the sprayed area, possible reduced reproductive success, or a shift in nest-site loyalty, all of which may be a result of reduced insect populations and food supply. Doane and Schaefer (1971, as cited in Dobroski, 1985) have suggested that the removal of gypsy moth larvae, which is an important food source for birds, could cause migration of birds out of treated areas.

Effects on Avian Reproduction. Studies indicate the possibility that extensive use of carbaryl may cause a significant reduction in reproductive success of avian species, especially quail and pheasant. DeRosa et al. (1976, as cited in EPA, undated) found residues of carbaryl in yolks of coturnix quail eggs produced 8.5 hours after treatment levels similar to those encountered in the field. Fecal analysis indicated that carbaryl residues were no longer present at 52 hours. Exposure to a second treatment caused significant reduction in egg production in direct proportion to treatment levels. Egg viability was not affected; however, agonistic behavior was decreased in males but increased in females after pesticide ingestion. The authors suggested that these behavioral modifications may disrupt pair formation in the field, thereby jeopardizing reproductive success.

DeWitt and Menzie (1961, as cited in EPA, undated) reported a reduction in chick production when quail were fed diets containing a total of 12,000 mg/kg or more of carbaryl during growth, winter, and production periods. Pheasants fed diets with 500 or more ppm carbaryl during the breeding season had a 50-percent reduction in chick survival. Depressed body weights were observed in quail fed diets containing 250 ppm or more carbaryl and in pheasants fed diets containing 1,000 ppm carbaryl. The percentage of growth depression in pheasants was roughly proportional to the daily intake of carbaryl.

Japanese quail fed 50, 150, 300, 600, 900, and 1,200 mg carbaryl per kg of feed (ppm) from the day of hatching to 14 weeks of age showed growth depression and increases in relative brain, liver, and kidney weights (Bursian and Edens, 1977, as cited in EPA, undated). A slight decrease in egg production and viability was observed at the 600, 900, and 1,200 ppm levels.

Zinkl et al. (1977, as cited in Lambert, 1985) also suggested that brain cholinesterase inhibition caused by treatment with 1 lb a.i./acre carbaryl may result in reduced reproductive success because birds would be unable to gather food or escape predation.

In a study involving exposure of eggs to pesticides, 40 percent of eggs injected with 5 mg of carbaryl hatched (Ghassemi et al., 1981). No eggs hatched that were injected with 2.5 mg each of malathion and carbaryl. These dosages are considered to be well above the expected environmental exposure. In another study, hen eggs injected with 100 and 200 ppm carbaryl in acetone killed 61 and 100 percent of embryos, respectively (Dunachie and Fletcher, 1969). Teratogenic effects were caused at 50 ppm and above.

Toxicity to Insects

Honey Bees. Carbaryl is very toxic to honey bees (Union Carbide, 1980, as cited in Dobroski, 1985). In honey bees, the 48-hour LD_{50} for direct exposure is 1.34 μg/bee for carbaryl dust and 1.02 μg/bee for Sevin® 4-Oil dust (Atkins et al., 1973, as cited in Dobroski and Lambert, 1984). Similar results were reported by Stevenson (1970, as cited in Dobroski, 1985). The LD_{50} for an adult bee by direct contact was approximately 1 μg or 10 to 15 mg/kg.

Carbaryl is more toxic to honey bees when ingested than from direct contact. The results of laboratory experiments indicate that the LD_{50} is 0.18 μg per bee when administered orally (Alvarez et al., 1970, as cited in Dobroski, 1985). Bees collecting pollen from treated areas may be killed in great numbers when walking over treated surfaces (Mayland and Burkhardt, 1970, as cited in Dobroski, 1985).

Older bees (normally the worker bees) are less susceptible to carbaryl (Mayland and Burkhardt, 1970, as cited in Dobroski, 1985) and may carry contaminated pollen to the hive before they sicken and die. The young and the reproductive members of the hive also may die from eating pollen (Johansen and Brown, 1972; Mayland and Burkhardt, 1970; Strang et al., 1968, all as cited in Dobroski, 1985). Once inside the hive, the contaminated pollen may remain toxic for months (Johansen and Brown, 1972; Moffett et al., 1970, both as cited in Dobroski, 1985).

If bees are removed beyond flight range from an area to be sprayed and not returned for 7 days after spraying, mortality is not significant (Atkins et al., 1975, 1977; Strang et al., 1968; Union Carbide, 1981, all as cited in Dobroski, 1985). Another method to reduce the effects of spraying carbaryl near bees is the deliberate feeding of corn pollen to the bees, which seems promising on an experimental basis (Moeller, 1972, as cited in Dobroski, 1985). Most recommendations include either moving the colony for a brief period or confining the bees to their hive before and shortly after spraying (Agriculture Research Service, 1967, 1977, both as cited in Dobroski, 1985).

Other Beneficial Insects. Because carbaryl acts as a broad spectrum pesticide (EPA, 1980, as cited in Dobroski, 1985), a certain amount of toxicity to a wide variety of insects and other arthropods may be expected. Many insects in the order Hymenoptera (this order includes the honey bees) seem to be especially susceptible to carbaryl (Abu and Ellis, 1977; Adams and Cross, 1967; Plapp and Vinson, 1977; Stern, 1963, all as cited in Dobroski, 1985). Ladybird beetles (Coccinellidae) also have been found to be very sensitive to carbaryl (Afify et al., 1970; Bartlett, 1963, 1966; Colburn and Asquith, 1971; Satpathy et al., 1968; Stern et al., 1959, as cited in Dobroski, 1985). In general, both groups of insects are regarded as beneficial insects because they act as predators and parasites of various insect pests. Comparatively less carbaryl is required to kill these beneficial insects than is needed to kill pest insects. Even parasites developing inside a treated host insect may be killed (Abu and Ellis, 1977, as cited in Dobroski, 1985), as will ladybird beetles feeding on poisoned aphids (Satpathy et al., 1968). A loss of these predators may occur in carbaryl-treated areas, but no permanent loss has been found in monitored spray programs (Root and Skelsey, 1969; Shepard and Sterling, 1972; Union Carbide, 1980, all as cited in Dobroski, 1985). A fairly rapid reestablishment of these beneficial insects by immigration from areas surrounding the treated area can be expected because little residual effect of carbaryl exists several days after spraying.

Carbaryl is not toxic to all members of the order Hymenoptera because at least one important pollinator of alfalfa, the alfalfa leafcutting bee, is only moderately susceptible to carbaryl (Johansen et al., 1963; Waller, 1969, both as cited in Dobroski, 1985). Other beneficial insects, such as the predaceous big-eyed bugs (Walker et al., 1974, as cited in Dobroski, 1985) and green lacewings (Plapp and Bull, 1978, as cited in Dobroski, 1985) are not severely affected by carbaryl.

Spiders and Mites. Spiders are not severely affected in carbaryl-treated fields (Shepard and Sterling, 1972, as cited in Dobroski, 1985), although they have been shown to be more sensitive to carbaryl when they ingest treated prey than when they walk over treated surfaces (Hagstrum, 1970, as cited in Dobroski, 1985). As shown in another study, spiders quickly return to treated areas within 3 weeks after spraying (Barrett, 1968).

Carbaryl is highly toxic to predatory mites but not as toxic to phytophagous (plant-feeding) mites (Bartlett, 1968; Dabrowski, 1969, 1970; Dabrowski et al., 1973, all as cited in Dobroski, 1985). One investigation (Croft and Jeppson, 1970, as cited in Dobroski, 1985) showed that carbaryl was less toxic to predaceous mites than was previously reported in the literature. Mite predators, such as the predaceous thrips, are also susceptible to carbaryl (Holdsworth, 1968; MacPhee and Sanford, 1961, both as cited in Dobroski, 1985). This difference in toxicity to mite predators may cause detrimental outbreaks of phytophagous mites.

Aquatic Toxicity

Fish. The LC_{50}'s of carbaryl for a number of aquatic organisms are shown in table F2-8. The toxicity of the technical formulation is greater than the 49-percent oil dispersion formulation (Sevin® 4-Oil). The acute aquatic toxicity of carbaryl is relatively low when compared to other insecticides. Members of the catfish (Ictaluridae) and minnow (Cyprinidae) families are nearly 10 times more tolerant of carbaryl than the trout (Salmonidae) family. The toxicity to sunfish and bass (Centrarchidae) is approximately midway in this range.

Acetylcholinesterase depressions (13 to 22 percent) have been observed in brook trout within 24 hours of spraying carbaryl at 1 lb/acre. Levels returned to normal within 48 hours. At the same application rate, Atlantic salmon (*Salmon salar* C.) showed average AChE depression of 20 percent. Levels did not return to normal within 48 hours (Hulbert, 1978; Marancik, 1976).

Invertebrates. Some aquatic insects in the orders Plecoptera (stoneflies) and Ephemeroptera (mayflies) are highly sensitive to low levels of carbaryl. Trichoptera (caddisflies) and Diptera (true flies) also are sensitive to carbaryl. There was a 50- to 100-percent reduction in aquatic insect populations in streams and ponds that were directly sprayed with carbaryl at 1.25 lb a.i./acre (Burdick et al., 1960, as cited in Dobroski, 1985). Mount and Oehme (1981, as cited in Fish and Wildlife Service, 1986) found that applications of 1.25 pounds of carbaryl per acre were not directly toxic to fish, but food items were reduced by 97.2 percent. LOTEL (1975) reported that in a stream treated with 1 pound of carbaryl per acre, each sampling station recorded a

Table F2-8—Acute toxicity of carbaryl to aquatic organisms

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (µg/L) (95% confidence interval)
Fish			
Rainbow trout[a]	12	1.5	1,950 1,450-2,630
Brook trout[a]	12	0.8	2,100 1,680-2,620
Brook trout[b]	12	1.3	4,500 3,948-5,066
Brook trout[c]	--	--	1,100-1,500
Cutthroat trout[a]	12	0.5	7,100 5,240-9,620
Cutthroat trout[c]	--	--	1,500-2,200
Brown trout[a]	12	0.6	6,300 5,520-7,190
Brown trout[c]	--	--	2,000
Lake trout[a]	12	1.7	690 520-910
Channel catfish[a]	18	1.5	15,800 13,900-18,000
Black bullhead[a]	18	1.2	20,000 18,000-24,000
Bluegill[a]	18	1.2	6,760 5,220-8,760
Bluegill[b]	17	0.7	39,000 29,732-51,157
Green sunfish	18	1.1	11,200 8,140-15,500
Yellow perch[a]	12	0.6	5,100 4,520-5,760
Largemouth bass[a]	18	0.9	6,400 4,400-9,200
Black crappie[a]	18	1.0	2,600 1,180-5,700
Fathead minnow	18	0.8	14,600 11,700-19,800
Carp[a]	18	0.6	5,280 4,620-6,050
Goldfish[a]	18	0.9	13,200 8,310-20,800
Invertebrates			
Simocephalus[a,d] (daphnid)	16	First Instar	7.6 6.2-9.3
Daphia pulex[a,d] (daphnid)	16	First Instar	6.4 4.5-8.9
Cypridopsis[a,d] (seed shrimp)	21	Mature	115 74-179
Asellus[a] (sowbug)	18	Mature	280 214-367

Table F2-8 (continued)—Acute toxicity of carbaryl to aquatic organisms

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (µg/L) (95% confidence interval)
Invertebrates (continued)			
Gammarus lacustris[a] (scud)	21	Mature	22
Gammarus fasciatus[a] (scud)	21	Mature	26 16-39
Procambarus[a] (crayfish)	12	Early Instar	1,900 1,160-3,110
Palaemonetes[a] (glass shrimp)	21	Mature	5.6 3.6-8.3
Pteronarcella[a] (stonefly)	16	Naiad	1.7 1.4-2.4
Pteronarcys[a] (stonefly)	16	Second Year class	4.8 3.0-7.7
Claassenia[a] (stonefly)	16	Second Year class	5.6 3.9-8.1
Skwala[a] (stonefly)	12	Naiad	3.6 2.4-5.5
Skwala[b] (stonefly)	7	First Year class	9.2 7.4-12.0

[a]Technical material, 99.5 percent.
[b]Oil dispersion, 49 percent.
[c]EPA, 1973, as cited in Dobroski, 1985.
[d]48-hour EC_{50}.

Sources: Johnson and Finley, 1980; Dobroski, 1985.

residue of at least 40 ppb and a peak residue of 80 ppb. The biological impact was indicated by increased drift of dead and dying stoneflies, mayflies, caddisflies, and true flies.

The effects of 2 consecutive years of spraying on other aquatic organisms appear similar to those observed in areas treated just once (Trial, 1978, 1979; Courtemanch and Gibbs, 1978). These effects include loss of stonefly species from individual streams and altered generic assemblages for an indefinite period (Trial, 1978, 1979). A study of buffered streams by McCullough and Stanley (1980) during the 1979 Maine spruce budworm spray project indicated that benthic invertebrate fauna were not adversely affected. Also, the numbers of drifting invertebrates were substantially lower than in previous years. The long-term impact appears to be a function of species susceptibility and recolonization ability. Two consecutive years of spraying with carbaryl reduced populations of stonefly and susceptible mayfly genera to near zero.

Carbaryl (Sevin® 4-Oil) was applied to woodland ponds in Maine at a rate of approximately 1.85 lb a.i./acre (0.84 kg a.i./acre). Caddisfly populations were temporarily reduced. Most severely affected were the amphipods (*Hyallela azteca*), which were reduced to nearly zero. This group failed to recolonize in some ponds for up to 30 months after spraying (Gibbs et al., 1984).

Aquatic Plants. Carbaryl was nontoxic to a species of fresh-water algae at 1 ppm. The growth rate of the algae actually increased after exposure to carbaryl; this was thought to be a result of the increase in available nitrogen (an important plant nutrient) from the degradation of carbaryl (Stadnyk et al., 1971, as cited in Dobroski, 1985). An increase in the algae growth rate after exposure to carbaryl also was reported by Murray and Guthrie (1980, as cited in Dobroski, 1985).

Concentrations of approximately 10 ppm carbaryl were lethal to three of five species of marine algae. Reproduction was not affected at 1.0 ppm. In one of the five species, growth was inhibited at 0.01 ppm (Ukeles, 1962 as cited in Dobroski, 1985).

Toxicity of 1-Naphthol. 1-Naphthol is the major microbial degradation product of carbaryl. In a laboratory study (Stewart et al., 1967, as cited in Dobroski, 1985), carbaryl was shown to be 30 to 300 times more toxic than 1-naphthol to crustaceans (shrimp and crabs). In the same study, 1-napthol was twice as toxic as carbaryl to fish and mollusks (mussels, clams, and oysters) (Butler et al., 1968; Stewart et al., 1967, both as cited in Dobroski, 1985).

Acephate

Mammalian Toxicity

Brain cholinesterase depression has been reported for small mammals after aerial spraying of acephate (0.5 lb a.i./acre) on forest plots in Idaho. Red squirrels recovered within 6 days after spraying, but Columbian ground squirrels had depressed cholinesterase levels 25 days after spraying (Zinkl et al., 1980, as cited in Dobroski, 1985). Recovery of stressed individuals, such as pregnant or nursing animals, could be somewhat slower. The acephate application rate for the Forest Service spruce budworm suppression program is 0.50 lb a.i./acre (1.5 oz a.i./acre).

Refer to the discussion about human health hazards in this section for details on the chronic toxicity, oncogenicity, teratogenicity, and mutagenicity of acephate on birds and mammals.

Avian Toxicity

Acephate is slightly to moderately toxic to birds. Hens had a reported oral LD_{50} of 360 mg/kg (304 mg/kg to 425 mg/kg) (EPA, 1984a). The oral LD_{50} for mallards is 234 mg/kg. Toxic symptoms that occurred when mallards were given lethal or near-lethal dosages included (in approximate order of onset): ataxia, imbalance, hopping and falling, jerkiness, mild spasms in the legs and feet, immobility, wing spread, and intermittent tremors (Hudson et al., 1984).

In field studies, results indicate that the effects of acephate on bird populations differ. Although no significant effects were observed in some areas, others showed significant declines in population numbers thought to be related to reduction in food supply. In addition, significant ChE inhibition was observed in several cases.

Songbird populations sprayed with acephate at rates of 0.09 to 6.5 lb a.i./acre were not adversely affected at two sites in eastern Canada. Surveys were performed for up to 6 days after spraying to detect changes in songbird populations and to identify dead or ill birds (Buckner and McLeod, 1975, as cited in Lambert, 1985).

A significant decline in red-eyed vireos occurred after treatment of a forested plot in New York with acephate at a rate of 0.5 lb a.i./acre. Whether the decline was a direct result of the pesticide or a result of a decline in the birds' food supply was not determined (Bart, 1979). Two vireo species abandoned treated areas, and singing activity of the crested flycatcher decreased after areas were sprayed with acephate. These reactions were considered responses to arthropod food supply distribution (LOTEL, 1975).

No direct mortality of wildlife was observed after aerially applying acephate at 1.5 oz a.i./acre on rangeland in Wyoming, Utah, and Arizona in 1979 and 1980, and in Wyoming in 1981 (McEwen and DeWeese, 1981). However, birds and small mammals did exhibit reduced brain cholinesterase activity in live specimens taken up to 24 days after spraying. The effects of sublethal brain cholinesterase reduction are largely unknown, but the literature indicates that the long-term biological and population effects may not be very great for depressions of less than 25 percent of brain cholinesterase. Potential short-term effects, however, could include inability to gather food, to escape predation, or to adequately care for young.

A number of other studies have reported significant depression of brain cholinesterase in songbirds following spraying of acephate at rates of 0.5 lb to 2.0 lb a.i./acre (Zinkl et al., 1977, as cited in Dobroski, 1985; Julin and Gramlich, 1978; Zinkl et al, 1980; Richmond et al., 1979, all three as cited in Lambert, 1985).

Studies by Zinkl et al. (1981, as cited in Lambert, 1985) with dark-eyed juncos and by Fleming and Bradbury (1981, as cited in Lambert, 1985) with mallards indicated that brain cholinesterase depression of more than 50 percent may be fatal. The latter study also concluded that there appears to be a threshold dose for acephate (and other organophosphate pesticides) that must be surpassed before inhibition of brain cholinesterase occurs. However, this threshold application rate has not yet been determined, and research has been suggested by the U.S. Fish and Wildlife Service (1986).

Recovery from acephate exposure also can be monitored by measuring brain cholinesterase over time. Recovery to about 80 percent of normal cholinesterase levels occurred within 10 days in bobwhite quail and mallards after 2 weeks on diets with 20 ppm acephate (Stelzes, 1982, as cited in Lambert, 1985). However, recovery of nesting birds, which would already be stressed, may be somewhat slower.

Lambert (1985) summarized in his review of the literature that "forest applications of acephate at recommended rates of 0.5 and 1.0 lb a.i./acre can be expected to produce physiological indications of organophosphorus intoxication in forest birds." Lambert also stated that recovery from sublethal doses of acephate appears to take only a few days.

Effects on Avian Reproduction. Avian reproduction studies showed no reduction in mallard egg production with 16-week dietary exposures of 5, 20, and 80 ppm technical acephate (Beavers et al., as cited in EPA, 1984d). However, duckling survival, up to 14 days of age, was reduced 20 percent at the 20- and 80-ppm levels; no effects were observed at the 5-ppm level. In bobwhite studies, egg production and chick survival were both significantly reduced at the 80-ppm level but were not affected at the 5- and 20-ppm treatment levels (Beavers et al., as cited in EPA, 1984d). In both studies, observed AChE inhibition increased with dosage and may suggest a basis for reduction in reproductive output.

Peterson et al. (1981, as cited in EPA, 1984d) reported no decrease in nesting success of rangeland birds on plots sprayed with 0.1 lb a.i./acre of acephate.

Effects on Honey Bees, Wild Bees, and Other Pollinators

Acephate is highly toxic to honey bees. The 48-hour LD_{50} for topical exposure to acephate dust is 1.2 μg/bee for honey bees (*Aphis mellifera* L.) (Atkins et al., 1973, as cited in Dobroski and Lambert, 1984). Laboratory and controlled field application tests conducted by Kupetz et al. (1979, as cited in Lambert, 1985) indicated the following LD_{50} values for acephate: oral (feeding studies), 1.07 μg/g body weight; topical (direct application), 5.4 μg/g body weight; and contact (with deposit on surfaces), 3,000 μg/100 cm^2 (2.7 lb a.i./acre as deposited).

Additional laboratory studies by Arzone and Vidano (1980, as cited in Lambert, 1985) indicated that acephate displayed a high oral toxicity to honey bees at doses 128 times lower than certain suggested crop-spraying

application rates, and acephate residues could remain lethal to honey bees upon contact for as long as 52 hours after application.

In Canada, acephate was tested as a possible control for spruce budworm (Buckner and McLeod, 1975, as cited in Lambert, 1985). Honey bees were placed in treated and untreated forest plots. Orthene® was applied at measured ground level rates ranging from 0.1 to 6.5 lb a.i./acre. In general, honey bees suffered population reduction, and the treatment affected nurse bees within the hives. These adverse effects were recorded for 2 days, and pollen collection was curtailed for up to 5 days. The impact on honey bee colonies was temporary, and seasonal honey production was similar for treated and controlled hives.

Moffett et al. (1979, as cited in Lambert, 1985) studied a number of measures to protect apiaries in areas where aerial spray applications of acephate may occur. In general, colonies directly in the path of the spray application suffered greater damage than colonies at the edges of the treated fields. Colonies close to alternate sources of pollen and nectar suffered less than colonies depending on the treated crops. Overall damage could be reduced by applying a combination of preventive management methods before and during spray applications.

Acephate was tested as a candidate control chemical for the Douglas-fir tussock moth as reported by Robinson and Johansen (1978, as cited in Lambert, 1985). Part of the test was to determine the effects of acephate on honey bees and other pollinators in the forest environment. Honey bee colonies in the path of aerial spray applications were all dead within 45 and 48 days after treatment, and colonies in untreated plots near the treated areas also were adversely affected. Data from this study indicated that foraging worker bees succumbed to the acephate in the field. Application rates were 1 and 2 lb a.i./acre on selected plots in the Wallowa-Whitman National Forest located in portions of the Blue Mountains and the Wallowa Mountains of northeastern Oregon (Davis et al., 1978, as cited in Lambert, 1985).

The results from this study are in contrast to earlier studies on plots in northern Idaho (Johansen, 1975, as cited in Lambert, 1985) in which acephate applied at 0.5 lb a.i./acre resulted in relatively low honey bee mortality and residual effects were negligible. This indicates that a number of factors may have been involved that directly affected honey bee intoxication. Some of these factors include application rate, weather conditions, and time of day of application. Johansen (1977, as cited in Lambert, 1985) classified acephate as a minimal hazard to honey bees if applied during late evening, night, or early mornings on blooming crops. The effect depends on the presence and concentration of contaminants in the pesticide formulation (including methamidophos) and proximity of alternative sources of pollen and nectar.

The Douglas-fir tussock moth study (Robinson and Johansen, 1978, as cited in Lambert, 1985) also addressed effects on other bees in the same forest plots. Bumblebees and mason bees were the prevalent wild bees, with bumblebees being the major pollinators of forest plants in the study area. Depressions in the numbers of foraging wild bees were apparent in all plots treated with acephate.

However, there was no apparent depression of wild bee populations in the same treated areas in the year following acephate application. The conclusion of the study was that a single application of acephate at an elevation of 4,000 to 6,000 feet is unlikely to cause either a severe or long-term impact because of reductions in insect pollination.

Acephate applied to three experimental plots in a northeastern Oregon forest at 1 and 2 lb a.i./acre had a devastating effect on ants of the genus *Formica* (Rousch and Akre, 1978, as cited in Lambert, 1985). The insecticide was applied during relatively cool weather. As the temperature rose, the foraging activities of the ants increased. Foraging material containing acephate was brought to the colonies, which were effectively dead 6 days after spraying. There was no recovery during the following year.

Aquatic Toxicity

Fish. Laboratory bioassays indicate that acephate is relatively nontoxic to fish, and lethal dosages are far greater than could be expected from normal spruce budworm operational application (Schoettger and Mauck, 1976). The acute LC_{50}'s of acephate for a number of aquatic organisms are shown in table F2-9. Tests by Johnson and Finley (1980) indicated that toxicity to trout, bluegill, or yellow perch was not affected by changes in water temperature, pH, or hardness.

Acephate application may change fish feeding habits (Rabeni, 1978). Quantitatively, there was an immediate postspray increase of number of prey and prey volume taken per fish. The number of terrestrial forms (beetles, moths, wasps, and particularly spiders) also increased after spraying and lasted 2 to 3 days before

returning to prespray levels. Prey volume per fish remained above prespray levels throughout the study period (8 days).

Rabeni (1978) found that acephate exposure depressed brain acetylcholinesterase activity in white suckers 28 to 29 percent postspray, and AChE activity returned to prespray levels in 8 days. Acetylcholinesterase activity was not depressed in brook trout or Atlantic salmon.

Bluegill sunfish (*Lepomis macrochirus* Rafinesque), yellow perch (*Perca flavescens* Mitchill), smallmouth bass (*Micropterus dolomieui* Lacepede), and bullheads (*Ictalurus nebulosus* LeSeur) were caged in a pond and observed for 2 weeks before and after an application of 0.5 lb acephate per acre. No mortality or behavioral changes were observed in any of the fish. (LOTEL, 1975).

Aquatic Insects. An acephate application of 0.5 lb a.i./acre resulted in decreased populations of caddisflies (Trichoptera) and true flies (Diptera); the decreases were temporary and significant only for midges (LOTEL, 1975). A similar application in Maine resulted in decreased populations of caddisflies and mayflies, but reductions were temporary and not detected 9 days after treatment (Rabeni and Gibbs, 1979).

Amphibians. Amphibians in larval or adult stages were not affected by forest applications of acephate at rates of 0.5 lb and 1 lb a.i./acre (Buckner and McLeod, 1975, as cited in Lambert, 1985). The 24-hour LC_{50} for tadpoles of the green frog is 6,433 mg/L (Lyons et al., 1976, as cited in Lambert, 1985).

Methamidophos

Mammalian Toxicity

Acephate degrades in the environment and is metabolized in animals to methamidophos, a more toxic compound. From 10 to 29 percent of applied acephate may degrade rapidly to methamidophos in the environment, depending on the substrate.

Methamidophos is about 40 to 70 times more toxic than acephate in rats, and 10 times more toxic than acephate in mice (Lambert, 1985).

Avian Toxicity

Studies examining the toxicity of acephate in birds (*Junco hyemalis*) have also detected residues of methamidophos (Zinkl et al., 1981, as cited in Lambert, 1985). EPA has required an avian residue monitoring study because of the high levels of the metabolite methamidophos found in avian foods after a 1 lb a.i./acre application of acephate (EPA, 1985).

According to EPA (1982b), methamidophos is very highly toxic to birds and highly toxic to mammals on the basis of a single dose (bobwhite quail LD_{50} = 8 mg/kg; rat LD_{50} = 13 mg/kg). NIOSH (1987) lists a rat LD_{50} of 7.5 mg/kg. Methamidophos is very highly toxic to birds in the diet (bobwhite quail LC_{50} = 42 ppm) but only slightly toxic to mammals in the diet (rat LC_{50} = 894 ppm).

Diesel Oil

Mammalian Toxicity

The discussion in the human health hazard subsection of this section provides details on the chronic toxicity, oncogenicity, teratogenicity, and mutagenicity of carbaryl. According to the American Petroleum Institute (1983c), the major hazards to mammals from diesel oil in the environment include the adherence of oil to the fur of animals, possibly resulting in hypothermia, and sublethal effects in small mammals from contaminated forage.

Toxicity to Beneficial Insects

Based on available studies, diesel oil appears to be highly toxic to honey bees, suggesting the potential for a high degree of toxicity to other invertebrates. Diesel oil caused high mortality to honey bees during the first 24 hours after spray treatment (Moffett et al., 1972). The authors also reported that the toxicities of the combinations of diesel oil and water, or diesel oil, water, and dimethylsulfoxide (DMSO) are less than diesel oil alone.

Table F2-9—Acute toxicity of acephate to aquatic organisms

Organism	Water temperature (°C)	Stage or weight (grams)	96-hour LC_{50} (µg/L) (95% confidence interval)
Fish			
Rainbow trout[a]	10	1.5	1,100
			775-1,561
Rainbow trout[b]	10	1.2	730
			580-920
Brook trout[a]	12	0.2	>100
Cutthroat trout[a]	12	0.7	>100
Cutthroat trout[b]	12	0.9	>100
Channel catfish[a]	22	2.0	>1,000
Channel catfish[b]	22	0.5	560-1,000
Bluegill[a]	20	0.4	>1,000
Bluegill[b]	20	0.4	>1,000
Yellow perch[a]	12	2.0	>50
Yellow perch[b]	12	1.8	>100
Largemouth bass[c]	--	--	1,725
Fathead minnow[a]	20	1.0	>1,000
Fathead minnow[b]	20	1.0	>1,000
Invertebrates			
Gammarus pseudolimnaeus[b] (scud)	12	Mature	>50
Pteronarcella[a] (stonefly)	12	Naiad	9.5
		7.3-12.3	
Skwala[a] (stonefly)	7	Naiad	12
Skwala[b] (stonefly)	7	Naiad	12
			8.0-18
Chironomus[a] (midge)	20	Fourth instar	>1,000
Amphibians			
Green frog tadpoles *(Rana elamitans)*[d]	--	--	6,433
			8.7-16

[a]Technical material, 94 percent.
[b]Soluble powder, 75 percent.
[c]Orthene® 75S. Chevron, 1976, as cited in Lambert 1985.
[d]24-hour LC_{50}. Lyons et al., 1976, as cited in Lambert, 1985.

Sources: Johnson and Finley, 1980; Lambert, 1985.

The use of adjuvants, such as spray oil, diesel oil, and surfactants, with insecticides caused slightly increased mortality of honey bees (Lagier et al., 1974).

Avian Toxicity

Diesel oil is very slightly toxic to orally exposed birds. The acute oral LD_{50} of diesel oil for mallard ducks older than 1 year is greater than 16,400 mg/kg (20 mL/kg) (Hudson et al., 1984). However, traces of oil in a mallard's diet sharply reduce egg production (Biderman and Drury, 1980, as cited in DOE, 1983). Furthermore, application of 5 µL of No. 2 fuel oil on mallard eggs significantly reduced hatching success to 18 percent (control group's hatching success was 88 percent) (Szaro et al., 1978). Survival and hatchability were significantly reduced even after application of only 1 µL of oil (Szaro et al., 1978). The authors reported that application of 20 µL of No. 2 fuel oil, which covered 20 percent of the egg surface, killed all embryos. Death occurred rapidly and appeared to be related to the aromatic portion of the oil rather than the aliphatic portion. Szaro et al. (1978) reported that surviving ducklings showed no gross external or behavioral abnormalities, and no significant differences in weights in comparison with controls at hatching. Similar toxicity of diesel oil was noted in pheasant eggs, which failed to hatch when sprayed with diesel oil to the point of runoff (Kopischke, 1972, as cited in DOE, 1983). Death occurred 1 to 2 days after oil was applied.

Pesticides in a relatively nontoxic oil carrier applied to mallard eggs were more toxic to embryos than when the pesticides were applied in a water carrier (Hoffman and Albers, 1984). The greater toxicity of the pesticide-oil mixture was attributed to the oil, which presumably caused an increased level of penetration of the pesticide through the shell and its membrane.

Aquatic Toxicity

Fish. Diesel fuel, jet fuels, and fuel oils are moderately to highly toxic to fish (based on the toxicity categories of Zucker, 1985). Jenkins et al. (1977, as cited in Burks, 1982) studied the acute and chronic toxicity of jet fuels to several fish species. They reported 96-hour LC_{50}'s (static tests) for the golden shiner (*Notemigonus crysoleucas*) of 0.68 and 0.94 mg/L for the jet fuels RJ-4 (a 12-carbon molecule) and RJ-5 (a 14-carbon molecule), respectively. They also reported a 97-day nonlethal concentration for rainbow trout (*Salmo gairdnerii*) of less than 0.03 mg/L for RJ-4 and 0.04 mg/L for RJ-5; and a no-effect level for eggs of the flagfish (*Jordanella floridae*) exposed by continuous flow to RJ-4 at 0.2 mg/L. Reduced hatchability was observed in flagfish eggs from exposure to RJ-5 at concentrations greater than 0.05 mg/L.

Acute toxicity tests with freshwater fish showing 96-hour LC_{50}'s of greater than 0.19 mg/L for diesel fuel and greater than 1.2 mg/L for No. 2 fuel oil have been reported by EPA (1976, as cited in DOE 1983). Tagatz (1961, as cited in Burks 1982) reported much lower toxicity, with a 48-hour LC_{50} for No. 2 fuel oil of 125 to 251 mg/L for juvenile American shad. His reported LC_{50} is based on the amount of oil applied to the surface of the water (nominal concentration) and not the water-soluble fraction; this may account for the apparent lower sensitivity of the shad.

The toxicity of No. 2 fuel oil has been studied for a number of marine fish and invertebrate species (table F2-10). The LC_{50}'s range from 0.81 to more than 6.9 ppm for marine fish and 0.21 to 14.1 ppm for invertebrates (Connell and Miller, 1984). The range of toxicity values determined for No. 2 fuel oil with marine species is useful in estimating the range of sensitivities for freshwater species because marine and freshwater species generally have a similar range of tolerance to toxicants (Sprague, 1985).

Irwin (1964, as cited in Burks 1982) calculated a "ratio of resistance" to allow the ranking of the sensitivities of 57 fish species to oil refinery wastewater. The guppy (*Lebistes reticulatus*) was least sensitive and was assigned a ratio of resistance of 100. The ratios of resistance for some of the common freshwater fish were as follows: rainbow trout (*Salmo gairdnerii*), 34.68; smallmouth bass (*Micropterus dolomieui*), 35.60; northern pike (*Esox lucius*), 37.31; fathead minnow (*Pimephales promelas*), 49.19; largemouth bass (*Micropterus salmoides*), 53.27; bluegill (*Lepomis macrochirus*), 54.10; and channel catfish (*Ictalurus punctatus*), 60.15. This study may be useful in predicting the relative order of sensitivities of these species to diesel fuels and other petroleum products.

Aquatic Invertebrates. The 96-hour LC_{50} for adult blue crabs (*Callinectes sapidus*) exposed to No. 2 fuel oil was 14.1 mg/L. No histopathological changes were observed in the gills, hepatopancreas, or muscles of the blue crab after 2 weeks of exposure to No. 2 fuel oil at 0 to 1 ppm (Melzian, 1983).

A spill of No. 2 fuel oil into a small stream in Virginia was acutely toxic to some fish, crayfish, and caddisflies. Two weeks after the spill, the density of benthic macroinvertebrates downstream was 25 percent

Table F2-10—Toxicity of light fuel oil to aquatic organisms

Species	Concentration (mg/L)	Effect	Source
Freshwater fish	>0.19[a] >1.2[b]	96-hr LC_{50} 96-hr LC_{50}	EPA, 1976, as cited in DOE, 1983
Rainbow trout	<0.03[c] 0.04[d]	97-day nonlethal level 97-day nonlethal level	Jenkins et al., 1977, as cited in Burks, 1982
Dolly Varden trout smolts	2.29[b]	96-hr LC_{50}	Connell and Miller,1984
Pink salmon	0.81[b]	96-hr LC_{50}	Connell and Miller, 1984
Golden shiner	0.68[c] 0.94[d]	96-hr LC_{50} 96-hr LC_{50}	Jenkins et al., 1977, as cited in Burks, 1982
Sheepshead minnow	>6.9[b]	96-hr LC_{50}	Connell and Miller, 1984
Saffron cod	2.93[b]	96-hr LC_{50}	Connell and Miller, 1984
Flagfish (eggs)	0.2[c] >0.05[d]	No effect level Reduced hatchability	Jenkins et al., 1977, as cited in Burks, 1982
Blue crab	14.1[b]	96-hr LC_{50}	Melzian, 1983
Grass shrimp Larvae Post larvae Adult	 1.2[b] 2.4[b] 3.5[b]	96-hr LC_{50}	Connell and Miller, 1984
Brown shrimp Late juvenile Adult	 2.9[b] 4.9[b]	96-hr LC_{50}	Connell and Miller, 1984
Dark shrimp	1.11[b]	96-hr LC_{50}	Connell and Miller, 1984
Humpback shrimp	1.69[b]	96-hr LC_{50}	Connell and Miller, 1984

Table F2-10 (continued)—Toxicity of light fuel oil to aquatic organisms

Species	Concentration (mg/L)	Effect	Source
Scooter shrimp	0.53[b]	96-hr LC_{50}	Connell and Miller, 1984
Pink shrimp	0.21[b]	96-hr LC_{50}	Connell and Miller, 1984
Polychaete (segmented aquatic worm)	2-4.2[d]	96-hr LC_{50}	Connell and Miller, 1984

[a]Diesel fuel.
[b]No. 2 fuel oil.
[c]Jet fuel RJ-4.
[d]Jet fuel RJ-5.

less than the density upstream from the spill, but species diversity was not affected. The density of the macroinvertebrates had returned to normal levels by 18 weeks after the spill (Hoehn et al., 1974, as cited in Burks, 1982).

Kerosene

Avian Toxicity

Kerosene was not lethal to embryos when applied to mallard eggs at doses of 1 to 50 µL/egg (Hoffman and Albers, 1984). The authors suggested that the low toxicity of the kerosene to embryos was related to its low aromatic hydrocarbon content. This may be evidenced by the low mortality of embryos exposed to a mixture of aliphatic hydrocarbons and the high mortality of embryos exposed to a mixture of aromatic hydrocarbons (Hoffman and Albers, 1984).

Toxicity Study Data Gaps

Data gaps for toxicity testing of malathion, carbaryl, and acephate are presented in table F2-11. Toxicity study data for the three pesticides in this hazard analysis were generally comprehensive. Adequate toxicity testing data existed to establish NOEL's for systemic and reproductive effects for the three pesticides. Toxicity study data that were not available in current literature included teratogenicity study data for malathion, reproduction study data for acephate, chromosome aberration mutagenicity study data for malathion, and primary DNA damage study data for carbaryl. The absence of this study data was not considered to have a deleterious effect on the quality of this analysis.

The study data for *Bacillus thuringiensis* (*B.t.*) generally was not specific for the delta-endotoxin (toxin present in the *B.t.* formulation used by the Forest Service); however, all study data on the delta-endotoxin available in the literature indicate that the delta-endotoxin is relatively nonhazardous to human health and wildlife.

Table F2-11—Data gaps in toxicity testing for malathion, carbaryl, and acephate

Test type	Insecticide: Malathion	Carbaryl	Acephate
Chronic			
Rat	X	X	X
Dog		X	X
Oncogenicity			
Rat	X	X	X
Mouse	X	X	X
Reproduction			
Rat	X	X	
Teratogenicity			
Rat		X	X
Rabbit	X	X	X
Gene mutation		[a]	X
Chromosome aberration		X	X
DNA damage	X		X

[a]Tests were performed on N-nitroscarbaryl.

Section F3

Exposure Analysis

This section gives the detailed information and calculations used to estimate insecticide exposures to humans, wildlife, and aquatic organisms that could occur as a result of spraying operations for spruce budworm suppression.

The first subsection describes the history of spruce budworm control, characteristics of the spruce budworm and its host species, and insecticide application for spruce budworm control. In the second subsection, mathematical models are used to estimate the transport of each insecticide and its fate in various environmental compartments. The third subsection presents the assumptions and calculations used to estimate insecticide exposures and resultant doses to humans. The fourth and fifth subsections describe the calculations used to determine exposures to terrestrial wildlife and aquatic species, respectively.

Factors Affecting Human And Environmental Exposure

Background and History of Spruce Budworm Control

The western spruce budworm, *Choristoneura occidentalis* (Freeman), is one of the most widely distributed and destructive defoliators of coniferous forest in North America (USDA, 1987a). *C. occidentalis* is one of eight budworm species that feed on foliage and cones of conifers in North America (Harvey, 1985). Although budworms feed on many conifers, six species are most heavily infested: Douglas-fir, grand fir, white fir, subalpine fir, Engelman spruce, and western larch (USDA, 1987b). Harvey (1985) reports, however, that the distribution of *C. occidentalis* does not extend much beyond the range of its principal host, Douglas-fir (Harvey, 1985; USDA, 1987b). The range of *C. occidentalis* encompasses southwestern, central, and northern Oregon; Washington; Southern British Columbia; and the Rocky Mountain States south to New Mexico and eastern Arizona. This risk assessment focuses on Region 6 of the Forest Service; the areas discussed in detail here will be primarily the States of Washington and Oregon.

Budworms are native to North American fir stands. The budworm population levels are normally held in check by the combined influences of parasites, predators, timber stand conditions, and weather. Periodic outbreaks occur because of imbalances in this control complex (USDA, 1987a). Outbreaks of western spruce budworm in the Pacific Northwest are not a recent phenomenon; the first outbreak was recorded in 1914 in Ashland, Oregon (USDA, 1987a). Before 1942, all outbreaks were small and subsided without causing appreciable timber loss (USDA, 1987a). The first major recorded spruce budworm outbreak in the Pacific Northwest lasted from 1943 to 1948, and an estimated 200,000 acres were defoliated. Since 1947, most areas have a fairly complete defoliation history based on aerial detection surveys. Since that time, most infestations have lasted only a few years. Outbreaks typically last from 6 to 10 years (USDA, 1987a).

At epidemic levels, budworms may defoliate entire timber stands, feeding primarily on new needle growth and affecting primarily Douglas-fir, grand fir, and white fir. Damage to host trees may include growth loss, top kill, deformity, reduced seed production, and mortality (USDA, 1987a). Visible defoliation from 1970 to 1985 covered an area in Oregon and Washington of more than 16.8 million acres, concentrated primarily in three areas: the Blue Mountains in northeast Oregon, the Cascades in eastern Oregon, and the Cascades in eastern Washington (USDA, 1987a). Because forest management is based on forecasts of productivity, or projections of forest growth and yield (that is, annual harvest is calculated from projected timber supply), budworm defoliation must be addressed to maintain the economic vitality of forest industries (MacLean, 1985).

Records indicate that management actions to suppress budworms in the Pacific Northwest began in 1949, when DDT was the insecticide of choice (USDA, 1987a). From 1949 until 1962, DDT was applied to more than 4.7 million acres in Washington and Oregon (USDA, 1987a). From 1976 until the present, a variety of insecticides have been used for budworm control, including malathion ULV, Sevin® 4-Oil (carbaryl), Orthene® (acephate), and Zectran® (mexacarbate). In addition, a microbial insecticide, *Bacillus thuringiensis*

(B.t.), has been used. Table F3-1 lists the potential insecticides to be used in the Oregon/Washington budworm supression effort.

The Target Species

The timing of the budworm life cycle varies considerably over its range, probably because of climatic variations (USDA, 1985a). In the northwest, the life cycle of the budworm, from egg to adult, occurs within 1 year (USDA, 1987a).

A few days after moths emerge in late July or early August, mating occurs and the female deposits her eggs on the underside of conifer needles. Eggs are laid in masses containing 3 to 130 eggs, with an average of 25 to 40 eggs (USDA, 1985a). Females usually lay some eggs where they emerge and mate, but they will fly elsewhere to deposit the remaining eggs (USDA, 1985a).

After about 10 days, the eggs hatch (USDA, 1985a). The emerging larvae spin silken shelters in branch scars, under bark scales, and among lichens on limbs and boles of the host tree where, with lowering temperatures, they will hibernate for the winter (USDA, 1985a). In early May, with warming temperatures, the larvae emerge and begin active feeding. Although budworms prefer succulent new growth, they also will feed on older foliage if new foliage is in short supply (USDA, 1985a). Some larvae also feed on pollen cones and seeds (USDA, 1985a). To accommodate their active growth, the larvae shed their skins (molt), usually a maximum of five times. The six intervening periods between molts are known as instars. After about 30 to 40 days, larvae are full grown and enter the pupa stage. Budworms pupate in webs of silk spun either at the last feeding site or elsewhere on the tree. The pupa stage lasts around 10 days, after which the moths emerge and begin the cycle again (USDA, 1985b). Spray programs are used during the 30- to 40-day larval feeding stage. The exact date of spraying is determined by weather and other environmental conditions (discussed later in this section).

The Host Species and their Environment

The western spruce budworm feeds on all age classes of many conifer species (USDA, 1987a). In the Pacific Northwest, budworm outbreaks occur in three major forest types: the true fir/Douglas-fir type, characterized by the host species; the ponderosa pine type, characterized by a true fir and Douglas-fir understory; and the white-fir type (USDA, 1985a).

There are a number of relationships between site/stand characteristics and infestation/damage by spruce budworm. Studies have shown a correlation between stand density and infestation (USDA, 1985a). Dense stands (increased crown closure) are more susceptible and vulnerable than open stands. In addition, mature stands, with larger stem and crown diameters, are more susceptible than younger stands. Spraying of these dense stands would provide for greater interception of insecticide by the overstory, with less of the insecticide available for penetration to the understory (where nontarget vegetation, fish and wildlife, and humans would be affected). Also, host stands of small acreage isolated in nonhost types have been found to be less susceptible than large, contiguous blocks of a host type. Because the most effective strategy is to spray the larger stands, the chances of missing the target areas and inadvertently spraying nontarget locales are much reduced, thus limiting the potential for human and environmental exposure.

In addition to the target trees, the target area contains a number of important plant species. Indians on reservations within the area, and perhaps individuals outside the reservations, harvest a number of edible plants (fruits and berries). A list of these plants is included in table F3-2. Additionally, a variety of vegetation exists in the riparian zones (that is, the area bordering streams, lakes, and wetlands that acts as a transitional area between the aquatic and upland zones) that is important as a source of food, cover, shade, and woody debris for fish and wildlife; for stabilization of banks; and, most importantly, as a filter to sediment transport from upland areas to streams (this would help prevent runoff of insecticide-contaminated material from entering adjacent streams). Riparian plant communities may be dominated by herbaceous species (mainly rushes, sedges, and grasses); hardwood species (mostly alder, bigleaf maple, willows, Oregon ash, or black cottonwood); or coniferous species (primarily western hemlock, sitka spruce, or western red cedar).

Thousands of miles of streams form the aquatic zones in the target areas and provide a home for a variety of aquatic lifeforms. These streams are habitat for a variety of game fish, including chinook salmon *Onchorhynchus tshawytscha)*, steelhead trout *(Salmo gairdnerii)*, and native trout. Aquatic insects that these

Table F3-1—Potential insecticides for spruce budworm control

Product name	EPA number	Registrant	Normal use rates[a]
Carbaryl			
Sevin® 4-Oil	264-323	Rhone-Pulenc, Inc.	0.5-1 lb a.i./acre
Sevin® 80 S	264-316	Rhone-Pulenc, Inc.	0.5-1 lb a.i./acre
Sevin® 50 W	264-314	Rhone-Pulenc, Inc.	0.5-1 lb a.i./acre
Acephate			
Orthene® Specialty Concentrate	239-2486-AA	Chevron Chemical Co.	0.5 lb a.i./acre
Orthene® 75 S	239-2418-AA	Chevron Chemical Co.	0.5 lb a.i./acre
Malathion			
Cythion® ULV Concentrate	241-208-AA	American Cyanamid Co.	0.9-1 lb a.i./acre
Bacillus thuringiensis			
Dipel® 6 L	275-48	Abbott Laboratories	
Dipel® 6 AF	275-59	Abbott Laboratories	
Dipel® 8 L	275-51	Abbott Laboratories	
Javelin®	55947-80	Sandoz Corp.	12 BIU/acre
Thuricide® 32 B	55947-62	Sandoz Corp.	
Thuricide® 48 LV	55947-74	Sandoz Corp.	
Bactospeine® WP	43382-2	PBI/Gordon Corp.	
Bactospeine® FC	43382-5	PBI Gordon Corp.	

[a]Actual application, including carrier, will be approximately 0.5 gallon per acre.

Table F3-2—Food plants found on Indian reservations and National Forests in the Northwest

Big leaf huckleberry	*Vaccinium membranaceum*
Camas	*Camassia quamash, C. leichtlinii*
Sawtik	*Perideridia gairdneri*
Black lichen	*Bryoria fremontia*
Chokecherry	*Prunus virginiana*
Bitterroot	*Lewisia deviviva*
Coush	*Lomatium cous*
Biscuitroot	*Lomatium cnabyi*
Piper's lomatium	*Lomatium piperi*
Indian celery	*Barestem lomatium*
Gray's lomatium	*Lomatium grayi*
Dwarf huckleberry	*Vaccinium caespitosum*
Blue-leaf huckleberry	*Vaccinium deliciosum*
Oval-leaf huckleberry	*Vaccinium ovalifolium*
Cranberry	*Vaccinium oxycoccus*
Dwarf Oregon grape	*Berberis nervosa*
Hazelnut	*Corylus cornuta*
Pine nuts	*Pinus albicaulus, P. lambertiana*
Strawberry	*Fragaria virginiana, F. vesca*
Serviceberry	*Admelanchier alnifolia*
Hawthorn	*Crataegus douglasii*
Elderberry	*Sambucus cerulea*
Acorns	*Quercus garryana*
Thimbleberry	*Rubus parviflorus*
Blackberries	*Rubus* spp.
Mint	*Mentha arvensis*
Mountain monardella	*Monardella odoratissima*
Skunk cabbage	*Lysichitum americanum*

Source: Helliwell, 1988.

fish feed on include mayflies *(Ephemeroptera)*, caddisflies *(Trichoptera)*, stoneflies *(Plecoptera)*, true flies *(Diptera)*, and damsel and dragonflies *(Odonata)*. In addition to these streams, several major reservoirs in the area provide drinking water for a number of cities and are used for recreation and livestock purposes.

Terrestrial wildlife species in the potentially affected areas include mule deer, black-tailed deer, black bear, silver grey squirrel, Rocky Mountain elk, California quail, mountain quail, blue grouse, spruce grouse, ruffed grouse, turkey, cougar, bobcat, lynx, and bighorn sheep (USDA, 1987a).

Land in the area is held by both private and public owners. Much of the land is used for forest management (USDA, 1987a). The target areas are relatively remote from population centers and residential areas. Compared with similar efforts used to suppress gypsy moths in the northeastern United States, the spruce budworm efforts would affect a significantly lower population density. The population density in even the most rural settings in the gypsy moth project is estimated to be 0.2 people per acre (1 person per 5 acres), while an average of 1 person per 75 acres may be found in the typical budworm spray areas. The potentially affected population includes residents within or adjacent (within one-quarter of a mile) to the National Forest boundaries (USDA, 1987a) and individuals engaged in firewood gathering and recreational activities, such as camping, hiking, fishing, hunting, swimming, and boating (USDA, 1987a).

The Insecticide Application Program

The various insecticides are proposed to be applied by helicopter or fixed-wing aircraft. Seed orchards and campgrounds may be treated with ground methods, such as backpack spraying. For aerial application, only aircraft capable of maneuvering and operating at slow airspeeds close to the tree canopy would be used; for example, a Bell 205 helicopter or a Turbo thrush fixed-wing aircraft. At slower airspeeds pilots can more easily identify hazards and treatment boundaries and can quickly shut off insecticide spray if necessary. In addition, low elevation application over treatment areas minimizes insecticide drift both within and away from target areas. Finally, observation aircraft flying at low speeds and elevations can more easily monitor insecticide release, deposition, and drift, and can note any mechanical problems that may be affecting appropriate application. Therefore, average air speed will be maintained between 80 to 100 mph, and the aircraft will dispense the insecticides at a height of about 50 to 75 feet above the vegetation. Electronic rotary atomizer spray nozzles will be used to deliver the insecticides. Median drop size will range from 100 to 150 microns in diameter. The anticipated maximum payload per aircraft will be 200 gallons. The largest area in a single watershed to be sprayed in 1 day will be 5,000 to 6,000 acres. The average swath will be maintained at approximately 100 feet, with 100-foot buffers maintained from private land and 500 foot buffers maintained from occupied dwellings. No buffer will be employed when using *B.t.*

The insecticides will be applied only when weather conditions favor effective insecticide penetration and dispersal into target areas. Operations will be prohibited when any one of the following conditions exist in the treatment area (insecticide label restrictions will take precedence over the conditions listed below when label restrictions are more limiting):

- Wind velocity is zero or exceeds 8 mph.
- The air temperature exceeds 70 °F or is less than 32 °F.
- Rain is predicted within 6 hours after application.
- Fog or other weather conditions limit visibility.
- Relative humidity is less than 50 percent.
- The air turbulence (thermal updrafts and so forth) is so great that it affects normal application.
- Low elevation air inversion is evident.
- Foliage is so wet that drops of water form at needle ends.

Before insecticide application, all application aircraft are calibrated and characterized. Calibration is the adjustment of the spray system so that the proper amount of insecticide is applied per unit area. Characterization is the evaluation of spray droplet size and determination of effective swath width. Also,

before application, the area to be sprayed (the spray block) is determined and ground observation, spray card, and plot tree locations (used for checking deposition and drift of applied material) are sited and established.

The pesticides will be stored in large storage tanks from which tank trucks will load the material for transfer to the location of the aircraft. The batch truck operator, mechanic/laborer, and load checkers will be involved in the pesticide transfer operations. After confirmation of weather details and examination of aircraft specifications, the application can begin. Numerous workers are involved in the spray operations. Table F3-3 lists these individuals and their estimated exposure times. Workers with the greatest exposure potential include the aircraft personnel (application pilot, aerial observers, and observation pilot), load checkers, ground observers, spray assessment crew, the biological (entomology) evaluation crew, the batch truck operator, and mechanics and laborers.

Ground observers are stationed outside of the spray block to monitor application and record weather information. The spray assessment crew (card crew) also is in the vicinity during application, but this crew is outside the actual treatment unit. These individuals wait in trucks for the material to dry on the spray cards (approximately 2 hours) before entering the treatment area to retrieve the cards. The card crew usually handles approximately 150 cards per spray day. For a spray area of approximately 150,000 to 200,000 acres, this would be repeated for 30 to 40 spray days. The period of actually contacting or brushing against treated vegetation will not exceed 1/2 to 1 hour per day. These cards will be analyzed to determine deposition and drift.

Finally, approximately 14 to 21 days after spraying, the biological evaluation (entomology) crew enters the spray area to assess larval mortality. The crew uses poles to clip branches instead of climbing trees. Foliage handling is limited to bud counting, placing the branch in the bag, and shaking the bag to dislodge larvae for counting.

Both before and during the insecticide application, the potential for accidents exists, thereby increasing the potential for exposure to the insecticides. Accidents may occur before the actual application; for example, a truck transporting insecticide to a aircraft site may be involved in an accident that results in a chemical spill.

During airborne application, accidents may occur because of mechanical failure of the aircraft, human error on the part of the pilot, or environmental conditions. Mechanical failure may result in loss of power or loss of maneuverability, or malfunctioning of the insecticide release mechanism, causing unintentional release. Mechanical failure may result in crash landings, unintentional release of spray in nontarget areas, or unintentional activation of the emergency release system, causing wholesale release of the payload. Human error may be the result of pilot misjudgment, causing loss of aircraft control, or unintentional insecticide release in nontarget areas. Finally, unforeseen environmental conditions may occur, such as strong gusts of wind, which may cause insecticide to spread to nontarget areas or a plane crash.

Insecticides

Most insecticides are packaged and sold by the manufacturer as a concentrate in liquid form, with a specified number of pounds of active ingredient per gallon of concentrate and with inert ingredients forming the remaining portion.

Before application, insecticides are mixed with a carrier (water for malathion and acephate and diesel oil for carbaryl) according to the manufacturer's label instructions for the particular treatment purpose and the desired application rate in pounds of active ingredient per acre. Insecticide concentrate, stored in 30- to 55-gallon drums, is prepared for application and then is transferred to application equipment by a mixer/loader, who uses a batch truck that has separate storage tanks for the carrier and for the insecticide mixture.

Table F3-3—Worker exposure times

Worker category	Number	Exposure: Days (actual spray days)	Exposure: Hours/day (actual)
Forest Service			
Director	1	12-15	2
Operations leader	1	12-15	2
Application leader	3	12-15	2
Aerial observers[a]	10	12-15	2
Load checkers[a]	5	12-15	2
Ground observers[a]	15	12-15	3
Spray assessment crew[a]	25	12-15	3
Biological (entomology) evaluation crew[b]	15	12-15	3
Safety officer	1	12-15	2
Law enforcement	4	12-15	2
Total	80		
Contractor			
Application pilot	10	12-15	2
Observation pilot[a]	10	12-15	2
Batch truck operator[a]	5	12-15	2
Fuel truck operator	5	12-15	2
Mechanic/laborer[a]	2	12-15	2
Total	32		

[a]Potential direct exposure during application.
[b]Potential delayed exposure (2+ hours after spray).

Note: The average treatment block will be approximately 2,000 to 10,000 acres.

Modeling Of Environmental Transport And Fate

Modeling of Insecticide Spray Drift

Spray Equipment and Spray Sites

In the spruce budworm suppression program, a variety of helicopter and fixed-wing aircraft are used for insecticide application. The choice of aircraft depends on a variety of factors, including the size of the area to be sprayed, volume per acre, topography, ferrying distance, available time, and the availability of aircraft.

The number of acres treated with insecticide each year in the spruce budworm suppression program can be quite large, but for the purpose of calculating exposures, it was desirable to identify typical treatment areas that represent spraying occurring on a single day in a single contiguous area. These areas were chosen to represent an amount that reasonably can be sprayed under favorable conditions. In practice, the area sprayed on a particular day (approximately 2,500 acres in 2 hours of spraying) is often smaller; occasionally it is larger.

The altitude of aircraft during insecticide application is typically 50 to 75 feet above the canopy. The altitude sometimes must be adjusted for topography because of unevenness or for safety reasons. Rotary atomizer nozzles are used for application. The maximum pesticide load of a helicopter is 200 gallons of mixture.

Estimation of Spray Drift

Estimation of spray drift is necessary to calculate exposures downwind of a spray site. The exposures considered in this EIS required estimating residues on the surfaces of people, animals, and plants; in water; and in the air.

The amount of insecticide that drifts downwind of a sprayed area depends on several important factors, including the following:

- Aircraft and spray system characteristics
- Spray formulation
- Meteorology
- Release height
- Canopy characteristics
- Topography

The pattern of insecticide deposition downwind of a spray aircraft can be quite complex, especially in areas close to the flight line where deposits are heaviest. The initial distribution of the spray cloud in the first few seconds after release is controlled by the interaction of the spray with the aircraft wake. Helicopters produce not only a vertical downwash of air, but also strong vortices originating from the rotor tips. The nature of the wake depends on the characteristics of the helicopter, especially its weight and rotor diameter, as well as its height and flight speed. At slow speeds, the vertical downwash is quite strong, but at the speeds typically used for spruce budworm spraying (80 to 100 mph), the wake forms a pair of tubular vortices that resemble those produced by fixed-wing aircraft. The aircraft wake also interacts with vegetation and is impeded by forest canopies.

Transport of the spray depends on the interaction of the wake with characteristics of the spray, which are determined by the chemical formulation and the spray equipment type and usage. The droplet sizes produced by the system are a principal consideration in controlling drift and in providing proper coverage to ensure efficacy. The distribution of droplet sizes can be only partially controlled with current technology, and a range of droplet sizes is always produced. The largest droplets fall out relatively quickly, while smaller droplets are dispersed more by turbulence and are carried farther. If droplets are too large, target coverage may be insufficient. Also, some dispersion of the spray is desirable to spread the swath more evenly and to

penetrate target foliage adequately. Spreading of the swath is predominantly downwind, and it allows swaths to overlap so that a more uniform coverage can be attained. However, if the spray is carried too far downwind, it is hard to control and may pose a hazard. Such uncontrolled transport of spray into nontarget areas is commonly called spray drift. The portion of the spray that is carried farthest is composed of the smallest droplets of insecticide in vapor phase that has evaporated either from airborne droplets or later from deposited droplets. The small droplets can be produced directly by spray equipment, or they can be a result of subsequent breakup or evaporation of larger droplets. Consequently, formulations, spray equipment, and conditions are designed to minimize the production of very small droplets.

In Region 6, rotary atomizers are normally used for insecticide spraying, and formulations are applied in a total volume of 0.5 gallon per acre. The formulations (described in an earlier section) may use a mineral oil carrier (for some *B.t.* formulations) or a diesel oil carrier (for carbaryl applications) or water (for malathion or acephate formulations). The median droplet sizes produced by the rotary atomizers range from approximately 100 to 150 microns, and the range of droplet sizes is well controlled subject to the limitations of available technology. Figure F3-1 shows the distribution of droplet diameters measured by Yates, Akesson, and Cowden (1984) for a Micronair AU 5000 spray system in a wind tunnel at 100 mph.

The distance that spray is transported also depends on meteorological conditions and the density of intercepting vegetation. Drift is controlled by making applications only when wind speeds are less than 8 mph. Conditions favoring evaporation are avoided by making applications only when relative humidity is greater than 50 percent and the air temperature is less than 70 °F. The forest canopy is typically dense enough to intercept most of the applied material, with typical tree heights of 75 to 100 feet and a significant understory.

Topography also can exert a relatively major effect on the degree of spray drift. Spruce budworm spraying is typically carried out in mountainous terrain, although relatively level lands also are sprayed. Yates, Akesson, and Cowden (1978) have shown that applications in mountainous terrain under some conditions can produce drift deposition as much as 10 times as high as on flat land.

For the purposes of this risk assessment, the study by Yates et al. (1978) has been used as a basis for calculating spray drift. This study was used because it investigated realistic spruce budworm spraying conditions, similar to those existing in Region 6, yet it represents a case that is conducive to spray drift in terms of topography and meteorology. Thus, the drift estimates used for the risk assessment are conservative and unlikely to underestimate drift.

Data from three of the trials reported by Yates et al. (1978) were used. The Forest Service conducted these trials on the Helena National Forest in Montana. Orthene® (acephate) was applied to two plots, and Dylox® 4 in oil was applied to the third. All of the applications were made by a Bell 205A helicopter using Beecomist Model 350 spray heads. The aircraft flew at 90 mph. All of the drift measurements were taken at the bottom of canyons below the treated areas during early morning hours when downslope winds occurred. The deposition measured on mylar sheets indicated that an average of 19 percent of the application rate was deposited at 500 feet from the plot (the range was 6.2 to 40 percent). This is equivalent to about 214 grams per hectare (g/ha) for a 1,120 g/ha (1 lb/acre) application rate. At 100 feet from the plot, the data indicate (by extrapolation) that an average of 59 percent of the application rate was deposited (ranging from 52 to 70 percent). This is about 664 g/ha at a 1,120 g/ha (1 lb/acre) application rate.

Yates et al. (1978) also measured concentrations of airborne droplets in these same tests by drawing air through glass fiber filters. When these observations were compared with the results of tests conducted on flat land, it was found that the airborne concentrations were significantly lower under the mountainous conditions. Consequently, again following a conservative approach, the results for the flat land test (using D6-46 nozzles) were used to estimate exposures for this risk assessment.

Based on exposures given by Yates et al. (1978), mean insecticide concentrations in air were calculated for the duration of the field tests (2 to 3 hours). Estimated concentrations were 9.16×10^{-3} mg/m^3 at 100 feet downwind and 4.58×10^{-3} mg/m^3 at 500 feet downwind.

Runoff Modeling

A second mode of potential human and environmental exposure is exposure to insecticides carried in rainwater runoff from sprayed areas. Aerially applied pesticides settle onto forest vegetation, soils, and water.

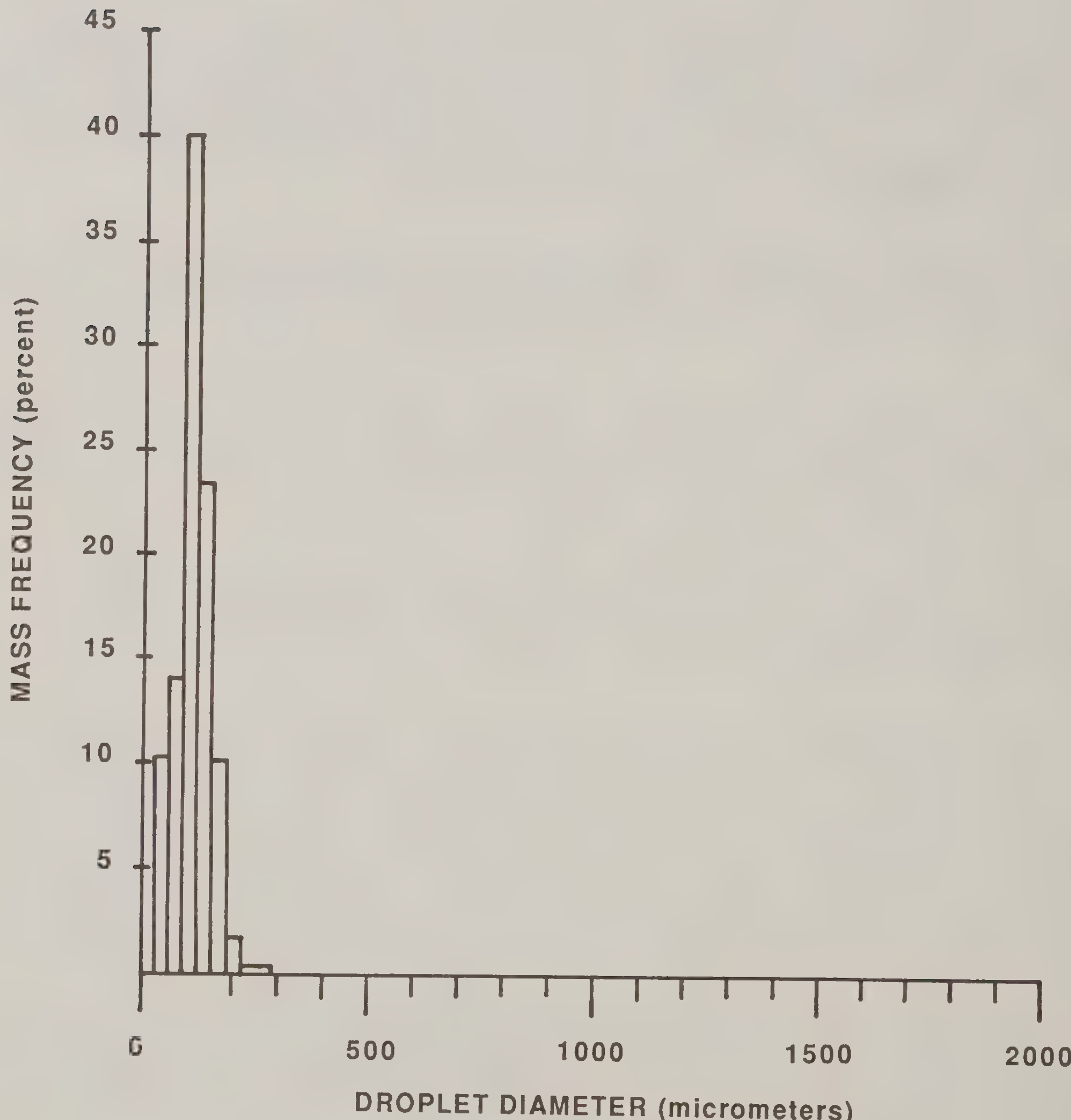

Figure F3-1—Frequency distribution of droplet diameters as a function of mass for a Micronair AU5000 rotary atomizer nozzle in a wind tunnel at 100 mph
Source: Yates, Akesson, and Cowden (1984)

Following application, pesticide concentrations decrease as the chemicals are degraded or adsorbed to organic matter in forest soils. Chemical properties of the pesticide, climatic conditions, and, to a lesser extent, the mode and rate of pesticide application, as well as vegetation and soils, determine the fate of applied pesticides. Carbamate and organophosphate insecticides (which include acephate and malathion) are known to be relatively nonpersistent in the forest floor and soil (USDA, 1980). The half-life of an insecticide is a parameter that describes the time it takes for concentrations (usually in soils) to be reduced by 50 percent as a result of all decay and degradation processes. Soil half-lives are calculated from decay constants (table F3-4) and range from 6.5 to 0.4 days.

When rain falls on a forested area recently sprayed, the amount of pesticide that enters a stream from surface runoff depends on the distance from the treated area to the stream, infiltration, and sorptive characteristics of the soil, and the rate of runoff. The persistence of the insecticide after it has entered the water is primarily a function of its chemical properties. Insecticide concentrations are reduced by volatilization, sorption, hydrolysis, photolysis, degradation, and dilution.

Conceptual Model

Insecticide concentrations should decline rapidly because of decay and degradation, and Forest Service protocol for pesticide application restricts spraying if a storm is predicted within 6 hours of application. However, if an unexpected large storm occurs in an area that has just been sprayed, a relatively high proportion of the pesticides may be washed into streams and transported into downstream reservoirs. This analysis examines the consequences of such an event on a typical watershed in the budworm infestation area. The analysis incorporates site-specific soils and climatic data and a hypothetical insecticide application scenario.

The Dalles Watershed Management Unit is approximately 41 square miles (26,000 acres) in area. No more than 5,000 acres in a single watershed are sprayed in a single day, which—in this case—represents approximately 19 percent of the total watershed. In assessing the potential for contamination of water resources, a worst case scenario was developed that would produce a high negative impact on the water quality in the watershed.

Spruce budworm eradication efforts normally take place during the mid-summer months. A worst case scenario assumed that three separate 5,000-acre subareas (A, B, and C in figure F3-2) are sprayed with insecticide on 3 consecutive days in July; and on the fourth day, a large rainfall occurs. The concentration of insecticides in the runoff from each separate subarea was calculated, and a mass balance equation was used to estimate concentrations in a downstream reservoir that receives the combined runoff. Using conservative assumptions about insecticide decay rates and dilution, a reasonable, conservative estimate of concentration was produced in runoff and in water that leaches into the subsurface.

Runoff Model

The Simulator for Water Resources in Rural Basins (SWRRB) model was developed (Williams et al., 1985) to predict how management decisions affect water and sediment yields on ungaged rural water basins up to several thousand square kilometers in area. The SWRRB model was constructed by modifying the CREAMS model (Chemicals, Runoff and Erosion from Agricultural Management Systems) to allow simultaneous predictions on several sub-basins. A version of SWRRB, called the Pesticide Runoff Simulator, was developed by the Office of Pesticides and Toxic Substances of the U.S. Environmental Protection Agency (Carsel, 1980) specifically to simulate pesticides in nonpoint source runoff. Version 3 of this model was used in all of the following simulations. SWRRB has been tested on 11 large watersheds throughout the United States and has been found to realistically simulate water and sediment yield in a wide range of conditions (Arnold and Williams, 1987). Honeycutt and Ballantine (1983) used SWRRB to estimate pesticide concentrations in nonpoint runoff and performed a sensitivity analysis of the model. They found SWRRB to be sensitive to rainfall intensity and pesticide parameters.

SWRRB contains the following four major components: weather, hydrology, erosion, and pesticide.

Weather. In contrast to more recent versions of SWRRB, EPA Version 3 requires daily rainfall, monthly temperature, and solar radiation as input. The model simulates daily air temperature and solar radiation based on a normal distribution.

Table F3-4—Insecticide characteristics

Pesticide	Kd	Foliar half-life (days)	Soil decay constant (day^{-1})	Application rate (lb/acre)
Acephate	0.1	2.8	0.17	0.50
Malathion	34.1	2.4	1.825	1.00
Carbaryl	2.2	6.8	0.1064	1.00

Source: Rose, 1988; Knisel, 1980.

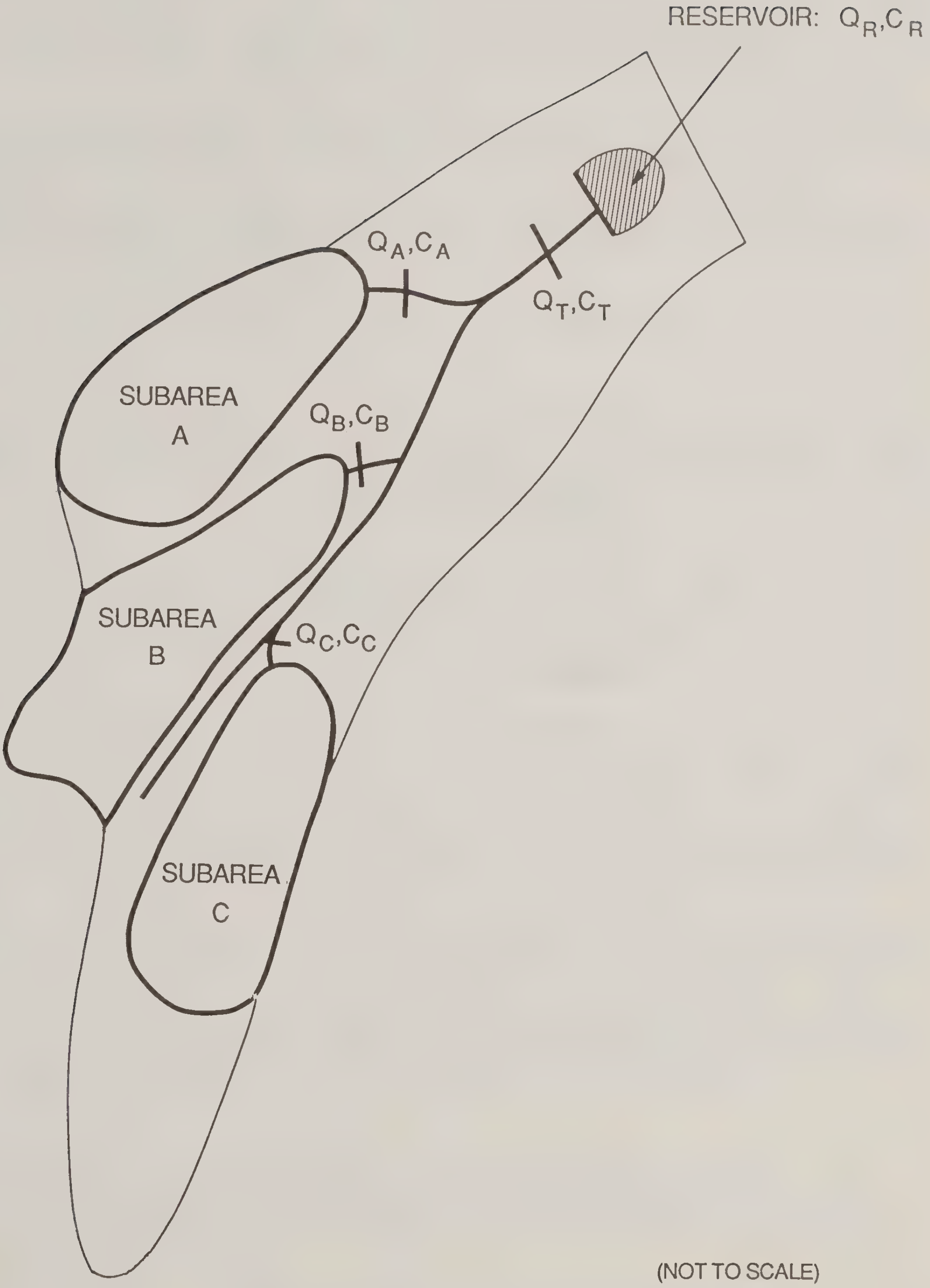

Figure F3-2—Schematic representation of a river basin in water quality modeling

Hydrology. Surface runoff is predicted using the Soil Conservation Service (SCS) curve number equation. Because the curve number (CN) varies depending on the amount of moisture in the soil, SWRRB uses a soil moisture accounting procedure to estimate a new CN for each storm. Evapotranspiration is computed with Ritchie's model using predicted daily temperature and solar radiation. Percolation through the root zone is computed with a storage routing technique that predicts flow through each layer.

Erosion. Sediment yield is calculated for each subarea using the Modified Universal Soil Loss equation. This equation predicts average soil loss based on soil type, agricultural management practices, and topography.

Pesticide. The pesticide component of SWRRB takes into account physical processes that affect pesticide concentrations such as adsorption to soil surfaces and sediments, degradation processes, and application efficiency.

Pesticide concentrations are estimated for nonpoint runoff and for water leached below the top centimeter.

Model Input

SWRRB requires two sets of data as input: a river basin set and a pesticide set. The river basin data set contains information required for the weather, hydrology, and erosion components of the model. Several subareas can be defined within a watershed; however, pesticide concentrations are estimated only for the total drainage basin. Each pesticide requires a separate data set.

To determine insecticide concentrations in runoff from each of the subareas as well as in the reservoir, each of the 5,000-acre subareas was modeled as a separate basin, and insecticide concentrations in the combined runoff were determined by mass-balance calculations. A schematic representation of the watershed is shown in figure F3-2. River basin characteristics used in modeling were largely the same for all subareas, differing only in soil properties. Insecticide data sets constructed for each subarea contain the assumption that subarea A was treated on the first day, followed by subarea B on the second day, and subarea C on the third day.

Three predominant soil types were identified from a soil survey of the Mt. Hood area (USDA, 1979). Each subarea was assigned a different soil type and corresponding values of the soil parameters. Representative values of these parameters are given in table F3-5. Site-specific data were obtained whenever possible from Forest Service scientists at Mt. Hood and from published reports. Other sources of data include the *SCS National Engineering Handbook* (USDA, 1972), *An Approach to Water Resources Evaluation of Non-Point Silvicultural Sources* (A Procedural Handbook) (USDA, 1980), and the *CREAMS Users Manual* (Knisel, 1980). Conservative values of soil and pesticide parameters were used when available.

The maximum precipitation of the 100-year, half-hour storm was estimated to be 3.67 inches (Lowrey, 1988). Because the model has a daily rather than hourly time step, this value was used as input on a single day after a 1-week dry period to represent the large rainfall event. Insecticides were applied to the forest subareas on each of the 3 days prior to the storm. Insecticide parameters and application rates are given in table F3-4. Application efficiency was assumed to be 100 percent, in line with the worst case scenario. A more realistic value for aerially applied pesticides is between 40 and 60 percent (Knisel, 1980).

Results

The combined peak runoff rate from the subareas (1,550 ft^3/sec) corresponds approximately to the measured inflow to the Crow Creek Reservoir resulting from the 100-year event that occurred in 1974 (1,471 ft^3/sec) (Dennee, 1988). In addition, runoff volume does not vary significantly between the three subareas (45.0 to 45.4 acre-foot).

Insecticide concentrations estimated by SWRRB are given in table F3-6. They vary roughly from 10 to 280 ppb. In all cases, contaminated runoff was derived from the one large storm. Between 97 and 99 percent of the applied malathion decayed on the ground or foliage, compared with 40 to 63 percent of the acephate, and 32 to 47 percent of the carbaryl.

Table F3-5—River basin characteristics

Common data used to model subareas A, B, and C

- Area = 7.81 square miles
- Root zone depth = 66 inches
- SCS curve number = 65
- Soil erodibility factor = 0.10
- Erosion control practice factor = 1.0
- Slope-length and steepness factor = 10
- Saturated hydraulic conductivity with depth = 3.0-0.2 in/hr

Characteristics of three most common soil types

- Bulk density (tons/cubic meter) = 1.22, 1.16, 0.92
- Porosity = 0.49-0.54, 0.41-0.51, 0.38-0.41
- Soil water content at 0.3 bars = 0.25, 0.24, 0.19
- Soil water content at 15 bars = 0.08, 0.06, 0.06

Source: USDA, 1979; Knisel, 1980; USDA, 1980.

Table F3-6—Estimated insecticide concentrations in runoff

Insecticide	Subarea	Runoff (inches)	Insecticide in runoff (lb/acre)	Runoff Concentration (ppb)
Acephate	A	0.108	0.00061	25
	B	0.109	0.00056	23
	C	0.108	0.00061	25
	Combined runoff			24
	Reservoir			3.6
Malathion	A	0.108	0.00040	16
	B	0.109	0.00054	22
	C	0.108	0.00085	35
	Combined runoff			24
	Reservoir			3.6
Carbaryl	A	0.108	0.00688	275
	B	0.109	0.00647	255
	C	0.108	0.00588	235
	Combined runoff			255
	Reservoir			39

Concentrations of insecticides in the combined runoff from the three subareas and in the reservoir were calculated by mass balance with the following simplifying conservative assumptions:

- Pesticide concentrations in runoff are constant throughout the runoff event.
- Runoff is not diluted by uncontaminated rainfall, ground water, interflow, or runoff from untreated portions of the watershed.
- All water in stream channels is derived from runoff.
- Complete mixing occurs in streams and in surface impoundments.
- Direct input of pesticides as a result of spraying surface water is negligible.

These conservative assumptions tend to overestimate insecticide concentrations. In general, concentrations in the reservoir resulting from inflow of runoff from treated areas range roughly from 3 to 40 ppb.

Modeling of Leaching

The SWRRB model also estimated insecticide concentrations in water leached below the top 1 centimeter of soil. Results (table F3-7) show that acephate and carbaryl have the potential to leach below the surface. An estimated 30 to 60 percent of acephate and 50 to 70 percent of carbaryl applied leach below the top 1 centimeter of soil, compared with approximately 1 percent of malathion. This is a function of the greater tendency of malathion to decay in soils (table F3-4). Estimated concentrations of acephate and carbaryl in the root zone are all less than 150 ppb. Pesticide concentrations in water in the plant root zone and in water that migrates below the plant root zone will be reduced by dilution and decay with time.

Leaching of pesticides is a slow process in highly organic forest soils and only small amounts of chemicals will move short distances (USDA, 1980). Studies have shown that degradation of acephate in water is accelerated because of breakdown by aquatic vegetation and microorganisms, which reduce concentrations to a negligible level after 1 to 9 days (USDA, 1980).

Modeling of Insecticide Contamination of Irrigated Crops

Humans may be exposed to insecticides by consumption of crops that are irrigated by water contaminated by insecticides. This scenario can be divided into three separate steps: contamination of water resources and application of the water to the crops, uptake of the insecticide by the plant, and consumption of the crops by humans.

Insecticides may be transported into surface waters used for irrigation by washing off plant surfaces into streams and lakes, by rainfall, and by drifting onto open bodies of water such as large rivers or reservoirs. The amount of insecticide that runs off a treated area depends on the intensity and duration of the rainfall, time between application of the insecticide and the rainfall event, type of ground cover, soil, land slope, and properties of the insecticide (Weber et al., 1980). A reservoir that has accumulated insecticides from drift may release the contaminated water for irrigation before degradation processes can reduce insecticide concentrations. Processes that reduce the concentrations and mobility of insecticides include sorption, volatilization, and degradation processes such as hydrolysis, photolysis, and microbial breakdown.

Some irrigation techniques, for example sprinkler systems, will aerate the water more than others and result in increased volatilization of the insecticide and reduced levels in the applied irrigation water. Thus, insecticide concentrations are likely to be higher in water applied using flood or gravity type irrigation systems.

The Crow Creek Reservoir of The Dalles Watershed Management Unit, located in the northeast section of the Mt. Hood Forest Service Region, is used as an example case to assess the risk of insecticide exposure to humans from irrigation water.

Table F3-7—Estimated insecticide concentrations in soil water

Insecticide	Subarea	Soil water (inches)	Pesticide leached (lb/acre)	Leachate concentration (ppb)
Acephate	A	3.63	0.180	35
	B	4.25	0.232	39
	C	3.78	0.298	56
Malathion	A	3.63	0.0099	1.9
	B	4.25	0.0149	2.5
	C	3.78	0.0250	4.7
Carbaryl	A	3.63	0.488	96
	B	4.25	0.565	94
	C	3.78	0.657	124

Insecticide Concentrations in Irrigation Water

Insecticides will not be sprayed directly onto irrigated fields, but reservoirs used for irrigation water may receive insecticide residue from spray drift or runoff. Plants that are subsequently irrigated with this water may accumulate insecticides, which could result in exposure to humans who consume the plants.

Water in the Crow Creek Reservoir is all allocated to the city of The Dalles, with the exception of 2 acres of irrigated land (Toll, 1988); it is piped directly from the outlet of the reservoir to a water treatment facility. Although in this case there is a negligible risk from consuming crops that have been irrigated by contaminated water, this example can be used as a conceptual model for the case where such a possibility does exist. Therefore, it is assumed that water from the reservoir is used for irrigated agriculture.

The Crow Creek Reservoir has a mean surface area of approximately 31 acres and a mean volume of 616 acre-ft, based on the average values from 1986 to 1987 (Toll, 1988). Because of the configuration of the reservoir, its surface area does not change significantly throughout the year; however, the volume of the reservoir may fluctuate by 200 to 300 acre-ft (Toll, 1988).

Insecticides are applied to the area surrounding the reservoir, leaving a buffer zone of 100 feet between the edge of the treated area and the edge of the lake. The drift rates of insecticide concentrations were measured on the ground 100 and 500 feet away from the treated land surface and were determined to be 664 and 214 g/ha (0.59 and 0.19 lb/acre), respectively.

The shape of the lake approximates a rectangle about two times as wide (north to south) as it is long (east to west). If a linear relationship is assumed between concentration and distance from application and drift rates and application rates are known (see table F3-8), the mass input of insecticide as a function of distance and the average mass input (mg/ft^2) can be calculated.

Based on the calculated mass input gradient of insecticide, concentrations derived from drift are negligible at a distance of 590 feet or more from the edge of the lake on the side that the insecticide is applied. The affected surface area of the lake is 969,370 ft^2, or approximately 70 percent of the total surface area of the lake.

Insecticide drift calculations take into account the volatilization of pesticide compounds. Neglecting decay processes that decrease insecticide concentrations, the concentration of compounds in the reservoir can be estimated by:

$$C_{water} = (MI)(ASA)/V$$

where:

C_{water} = concentration of insecticide in water (mg/L)
MI = average mass input of insecticide (mg/ft^2)
ASA = affected surface area of reservoir (ft^2)
V = volume of water in reservoir (L)

Estimated insecticide concentrations in the reservoir water are given in table F3-9.

Uptake of Insecticides by Vegetation

The concentrations of insecticides in irrigated crops are calculated based on relationships between the soil, water, insecticide, and crop plants. The following assumptions were used to simplify calculations:

- Chemical equilibrium is rapidly established between insecticide concentrations in the soil and the soil water.
- Insecticide concentrations in the soil water can be considered constant over the exposure period of the plant, which is related to the half-life of the insecticide.
- Chemical equilibrium exists between insecticide concentrations in all plant parts.

Table F3-8—Insecticide application rates and mass inputs

Compound	Application rate (lb/acre)		Mass input (mg/ft^2)		
	Typical	Worst case	Typical	Worst case	Average
Acephate	0.5	0.5	0.994	3.09	1.55
Carbaryl	1.0	1.0	1.98	6.17	3.09
Malathion	0.9	1.0	1.79	6.17	3.09
Diesel oil	0.85	1.7	1.69	10.5	5.25
Kerosene	0.24	0.49	0.474	3.02	1.51

Table F3-9—Average mass input of insecticide and estimated concentrations in Crow Creek Reservoir, The Dalles Watershed Management Unit, Oregon

Compound	Average mass input (mg/ft^2)	Concentration (mg/L or ppb)
Acephate	1.55	1.98
Carbaryl	3.09	3.95
Malathion	3.09	3.95
Diesel oil	5.25	6.72
Kerosene	1.51	1.93

- Insecticide concentrations in plant material do not decrease after exposure ceases.

- Soil organic carbon content is spatially variable but can be approximated by an average value.

- Effects of volatilization on the aqueous concentration of the insecticide are less than those from sorption, and they can be initially neglected.

- Calculated insecticide concentrations that neglect degradation processes (photolysis, hydrolysis, and microbial degradation) yield values that can be used as an upper bound.

To simplify the calculations, the time dependence of aqueous insecticide concentrations, which are both volatilized and degraded after application, is neglected. The effect of the latter two assumptions listed above is to overestimate concentration of the insecticide both in the aqueous phase and in the plant. An estimate of time-dependent insecticide concentrations can be obtained using a model, such as GLEAMS (Leonard et al., 1987) or the PRZM (Carsel et al., 1984) model, which take into account degradation and volatilization of the insecticide using empirically derived decay constants.

Bioconcentration. The bioconcentration of organic compounds by vegetation is traditionally measured by a bioconcentration factor (B_v), which is defined as the ratio of the concentration of the chemical in plant tissue to the concentration of the chemical in soil.

A study by Travis and Arms (1988) determined an empirical relationship between bioconcentration factors for organic chemicals in vegetation, and the octanol-water partition coefficient (K_{ow}) of the chemical. A geometric mean regression of these parameters for 29 chemicals used on vegetation determined that the relationship is as follows:

$$\log B_v = 1.588 - 0.78 \log K_{ow}$$

The correlation coefficient (r) of these data is 0.73. The inverse relationship between B_v and K_{ow} indicates the dependance of insecticide concentrations in the plant on uptake of the soluble fraction of the insecticide from soil water in the plant's root zone. Aqueous solubility is inversely proportional to K_{ow}. The concentration of the insecticide in the soil water was assumed to be constant over the period of the experiment (Arms, 1988).

Although the study by Travis and Arms did not include the specific insecticides under consideration at this site, they included a variety of classifications of insecticides. Therefore, this empirical formula (shown in the equation above) can be used to calculate bioconcentration factors of insecticides for this study (Arms, 1988):

Compound	K_{ow}	B_v
Acephate	0.0428	239
Carbaryl	651	0.916
Malathion	776	0.827
Diesel oil (octane)	10,000	0.189

Partitioning of Insecticides Between Soil and Water Phases. Acephate, carbaryl, and malathion can be expected to sorb to organic matter in the soil to varying degrees, depending to a large extent on the hydrophobicity of the insecticide. Sorption effects can be estimated by taking into account the percent organic matter in the soil, the concentration of the insecticide in water applied to the soil, and the organic carbon partition efficient (K_{oc}) of the soil.

The organic carbon partition coefficient (K_{oc}) describes the equilibrium relationship between the insecticide solution and the sorbed phase. K_{oc} is calculated from the distribution coefficient (Kd) of the insecticide, normalized for the fraction of organic carbon (OC) in the soil:

$$K_{oc} = Kd/OC$$

Experimental values of K_{oc} and Kd are given in Attachment F-A.

Soils found in the Mt. Hood Forest Service Region are derived mainly from weathered volcanic rocks. The percentage of organic matter in The Dalles Watershed soils estimated from mapped soil units ranges from 0.53 to 5.32, with an average of approximately 3 percent (USDA, 1979).

Insecticide Concentrations in Irrigated Crops

The concentration of insecticides in vegetation can be estimated from the concentration of the insecticide in the soil and the bioconcentration rate of the insecticide:

$$C_{plant} = (C_{water})(K_{oc})(OC)(B_v)$$

where:

C_{plant} = concentration in the plant (mg/kg)
C_{water} = concentration in the water (mg/L)
K_{oc} = organic carbon partition coefficient (L/kg soil)
OC = fraction organic carbon of soil
B_v = bioconcentration factor [(mg/kg plant)/(mg/kg soil)]

Estimated concentrations of insecticides in plants are given in table F3-10.

Exposure Calculations For Humans

Results of the environmental transport and fate modeling give estimates of insecticide concentrations in environmental components that may lead to human exposures. Those exposures are estimated in this analysis using scenarios that represent likely exposure routes and persons at risk. Exposures are assumed to occur both in routine insecticide spraying operations and in accidents. This section describes the calculation of human exposures for both routine and accident scenarios. The results of the human exposure analysis are presented later in this chapter. The calculated exposures represent a full range of the kinds and magnitude of exposure that could occur, while restricting the calculations to a reasonable number of cases. To avoid underestimating exposures, many parameters and assumptions were chosen so that calculated exposures would err on the high side. The exposure scenarios assume that some required operational procedures are disregarded.

Some of the exposures are described as routine, meaning that they could occur under routine circumstances, but only if conditions are conducive to exposure. If operational procedures are complied with, average exposure would be lower. Routine exposures were further divided into typical and worst case exposures. Typical exposures throughout the analysis were based on typical application rates and spray drift at 500 feet offsite from a treated area. Worst case exposures were based on worst case application rates and drift at 100 feet offsite.

Exposures also have been calculated for accidental situations that range from those likely to occur occasionally, for example, the direct spraying of a worker, to those that are very unlikely, for example, jettison of a full load of insecticide into a drinking water source.

Exposure and Dose

For a human to receive a toxic insecticide dose, two primary conditions are necessary. First, the insecticide must be present in a person's immediate environment so that it is available for intake, such as in the air a person breathes, on a person's skin, or in a person's food or water. The amount of insecticide present in a person's immediate environment is the exposure level. Second, an insecticide must get into a person's body by some route. If an insecticide is in the air, it may be inhaled into the air passages and lungs. If it is on the clothing or skin, it may penetrate the skin. If it is on food or in water, it may be consumed. The amount of insecticide that moves into the body by any of these routes constitutes the dose.

Thus, although two people may be subjected to the same level of exposure—for example, two ground observers—one may receive a much lower dose than the other by wearing protective clothing, using a respirator, or washing immediately after spraying. Exposure, then, is the amount of insecticide available to be taken in; dose is the amount that actually enters the body.

Table F3-10—Estimated concentration of insecticides in plants irrigated by contaminated water

Compound	Concentration (mg/kg plant or ppb)
Acephate	38.76
Carbaryl	24.97
Malathion	176.4
Diesel oil	209.6
Kerosene	60.2

Potential Routes of Human Exposure

The routes of exposure considered in this risk assessment in estimating doses to workers and the public that might occur during routine operations or in the event of an accident are listed in table F3-11 and are described below.

Potential Human Exposure From Routine Operations

The greatest doses to humans in routine insecticide applications are to workers who may be exposed while (1) mixing and loading insecticide into application equipment, (2) applying insecticide using aircraft, or (3) supervising or monitoring aerial insecticide applications. In general, the use of protective clothing and equipment and adherence to proper cleanup procedures and label precautions lead to significant reductions in doses to workers.

The most significant source of exposure to persons who do not handle the insecticide containers or spray equipment in routine operations is from off-target drift of airborne insecticide spray droplets. Spraying only under favorable weather conditions reduces the amount and extent of drift.

During routine operations, workers may be dermally exposed to an insecticide if the insecticide concentrate, mixture, or drifting spray droplets contact the skin or if the insecticide is brushed off of sprayed vegetation. Inhalation exposure may result from breathing without protective devices in the area of the drifting spray droplets or where there are vapors from a volatile insecticide. However, a variety of studies have shown that inhalation exposure is very small compared with dermal exposure.

Members of the general public who are within the area of drift of the spray droplets may also receive dermal and inhalation exposure, but their exposures are likely to be relatively low compared to the exposures of workers directly involved in the spraying operations.

Insecticide may be ingested by members of the public from food containing insecticide residues. Food items such as garden vegetables, wild berries, or game animals may have received some level of insecticide from spray drift. Game animals may have fed on plants from the spray area. Ingestion exposure could also result from drinking water or eating fish from a body of water exposed to insecticide drift.

Potential Human Exposure From Accidents

If an accident occurs, workers and members of the public may be exposed to much greater amounts of insecticide than they would under normal circumstances. Workers who spill the concentrate or some of the prepared spray mixture on their skin during mixing, loading, or spraying operations or who are doused when a transfer hose breaks would be dermally exposed. Workers or members of the public who are accidentally sprayed with insecticide because they are beneath a spray aircraft also would receive a dermal dose.

The dermal dose would depend on the concentration of insecticide in the spray mix, the area of the sprayed person's exposed skin, the extent to which the person's clothing absorbed insecticide (some clothing is water repellent, but other material would permit penetration of the insecticide to the skin), and the time that elapses before the person can wash. Indirect dermal (reentry) exposure may occur if workers or members of the public brush against wet vegetation in the sprayed area.

Members of the public may be accidentally exposed to the insecticide by eating food or drinking water that has been directly sprayed. For example, members of the public may eat berries that have been directly sprayed, or they may eat meat from deer that have recently foraged on a sprayed site. Exposure to even higher levels of insecticide is possible if a container of insecticide concentrate were to break open and spill into a drinking water supply.

Effect of Body Size on Exposure

All doses estimated in the exposure analysis were calculated for a representative 70-kg person (approximately 150 pounds). This weight was chosen to represent an adult of average weight.

Table F3-11—Routes of exposure evaluated in this risk assessment for workers and members of the public

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Workers
- Pilot - Inhalation and dermal
- Mixer/loader - Inhalation and dermal
- Observer - Inhalation and dermal
- Card checker - Dermal
- Entomology efficacy team member - Dermal

Public
- Nearby residents or recreational users of forest
  - Dermal from vegetation contact
  - Dermal and inhalation from drift
  - Dietary from consumption of water, fish, deer meat, garden items (peas or beans), wild berries

- Fisherman - cumulative exposure - dermal (vegetation contact) and dietary (water and fish)

- Hunter - cumulative exposure - dermal (vegetation contact) and dietary (water, wild berries, and deer meat)

Accidents
- Spill of insecticide concentrate onto worker - dermal
- Broken hose spilling insecticide mixture onto worker - dermal
- Direct spraying of an adult - dermal
- Direct spraying of a child - dermal
- Eating peas or beans that were directly sprayed - dietary
- 200-gallon spill of insecticide into drinking water supply - dietary

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Doses for a smaller person would be greater in terms of milligrams per kilogram of body weight. For example, a 70-kg person would receive approximately 2.3 times more insecticide than a 20-kg person by dermal exposure because the surface area of each is different. A 70-kg person also would receive on average about 2.3 times more insecticide by dietary exposure routes because both body surface area and metabolism are approximately proportional to body weight raised to the 2/3 power:

$$\frac{(70)^{2/3}}{(20)^{2/3}} = 2.3$$

A 70-kg person also has a body weight greater than a 20-kg person, by a greater factor:

$$\frac{70}{20} = 3.5$$

The combined effect of these two factors is that a 20-kg person will receive a dose in milligrams per kilograms that is about 1.5 times greater than that received by a 70-kg person.

Exposures to workers and members of the public from the three insecticides, from *B.t.*, diesel oil, kerosene, and from the combined petroleum distillates, are shown in tables F3-12 through F3-18.

Exposures to Workers

Pilots and Mixer/Loaders

Exposures to pilots and mixer/loaders were estimated from a field monitoring study by Atallah et al. (1982). This study has been used to estimate worker exposures by the Exposure Assessment Branch of EPA (Reinert and Severn, 1985). In this study, respiratory exposures were measured with air sampling tubes and a calibrated air sampler attached at the waist. Dermal exposures were measured from hand rinses and denim patches attached to the face, the back of the neck, the front of the neck, the "V" of the upper chest, and the forearms. For this analysis, the dermal and respiratory exposures (reported as µg/8-hour workday) in this study were averaged for each of the worker categories and adjusted to an average application rate of 1 lb/acre. The average dermal exposures were 3,009 µg/8 hours for pilots and 6,774 µg/8 hours for mixer/loaders. The average inhalation exposures were 13.4 µg/8 hours for pilots and 18.9 µg/8 hours for mixer/loaders.

Typical doses to workers for the spruce budworm project were calculated using the average adjusted exposure values described in the preceding paragraph and the application rate and dermal penetration rate of each chemical. The exposures also were adjusted for the number of hours worked per day. Workers were assumed to wear no special protective clothing and have a body weight of 70 kg. For worst case exposures, the upper 95-percent confidence limit from the Atallah et al. (1982) study was used. Worst case exposures also included the high application rates.

Exposures on sprayed sites and those resulting from accidental direct spraying were based on the full planned application rates in pounds per acre. Exposures at 100 and 500 feet from the spray site are based on the aerial spray drift model described previously. It was assumed that the wind blows directly from the spray site and that the terrain is steep. Under actual conditions, spray drift should be less than estimated in this analysis. Operational procedures require spraying when winds are less than 8 miles per hour and under other conditions that minimize drift.

Dermal penetration of malathion was estimated to be 8.2 percent for forearm skin, based on a study of human subjects (Feldmann and Maibach, 1974). Dermal penetration of carbaryl was estimated to be 73.9 percent, based on the same study. Dermal penetration of diesel and petroleum oils was estimated to be 25 percent. Dermal penetration of acephate was estimated to be 10 percent, based on a comparison of oral and dermal LD_{50} values (Curley and Donohue, 1986). These penetration estimates were expressed as fixed percentages based on dermal exposure studies that occurred over extended periods of time. In fact, dermal penetration is time dependent. If a person washes within the first few hours after exposure, penetration will actually be

Table F3-12—Acephate doses

Exposure scenario	Dose (mg/kg/day) Typical	Worst case
Public		
Dermal		
Vegetation Contact	0.00021	0.00021
Dermal & inhalation drift	0.00293	0.00900
Dietary		
Water	0.00050	0.00155
Fish	0.00125	0.00388
Meat	0.00023	0.00070
Peas or Beans	0.00391	0.00996
Berries	0.00196	0.00520
Cumulative		
Fisherman	0.00197	0.00565
Hunter	0.00290	0.00767
Workers		
Pilot	0.00056	0.00162
Mixer/loader	0.00124	0.00489
Observer	0.00293	0.00900
Card checker	0.00715	0.01088
E.E. team	0.00000	0.00000
Accidents		
Spill onto worker		85.7143
Broken hose		2.1429
Accidental spray of adult		0.0149
Accidental spray of child		0.0223
Spill into water--200 gallons into pond		1.0522

Table F3-13—Carbaryl doses

Exposure scenario	Dose (mg/kg/day) Typical	Worst case
Public		
Dermal		
Vegetation contact	0.00316	0.00316
Dermal & inhalation drift	0.04224	0.13087
Dietary		
Water	0.00100	0.00311
Fish	0.03510	0.10892
Meat	0.00087	0.00358
Peas or Beans	0.00782	0.01991
Berries	0.00391	0.01040
Cumulative		
Fisherman	0.03927	0.11519
Hunter	0.00894	0.02025
Workers		
Pilot	0.01198	0.02328
Mixer/loader	0.02692	0.07125
Observer	0.04224	0.13087
Card checker	0.05585	0.11207
E.E. team	0.01341	0.05255
Accidents		
Spill onto worker	1,266.8572	
Broken hose	633.4286	
Accidental spray of adult	0.2202	
Accidental spray of child	0.3302	
Spill into water--200 gallons into pond	2.1043	

Table F3-14—Malathion doses

Exposure scenario	Dose (mg/kg/day) Typical	Worst case
Public		
Dermal		
Vegetation contact	0.00027	0.00030
Dermal & inhalation drift	0.00374	0.01270
Dietary		
Water	0.00090	0.00311
Fish	0.00023	0.00078
Meat	0.00039	0.00130
Peas or Beans	0.00704	0.01991
Berries	0.00352	0.01040
Cumulative		
Fisherman	0.00140	0.00418
Hunter	0.00508	0.01511
Workers		
Pilot	0.00072	0.00230
Mixer/loader	0.00158	0.00690
Observer	0.00374	0.01270
Card checker	0.00956	0.01597
E.E. team	0.00171	0.00853
Accidents		
Spill onto worker		279.9000
Broken hose		3.0000
Accidental spray of adult		0.0209
Accidental spray of child		0.0366
Spill into water--200 gallons into pond		2.1043

Table F3-15—Diesel oil doses

Exposure scenario	Dose (mg/kg/day) Typical	Worst case
Public		
Dermal		
Vegetation contact	0.00091	0.00182
Dermal & inhalation drift	0.01224	0.07564
Dietary		
Water	0.00085	0.00528
Fish	0.00277	0.01716
Meat	0.00047	0.00326
Peas or Beans	0.00655	0.03385
Berries	0.00333	0.01768
Cumulative		
Fisherman	0.00453	0.02426
Hunter	0.00555	0.02804
Workers		
Pilot	0.00232	0.01351
Mixer/loader	0.00520	0.04117
Observer	0.01224	0.07564
Card checker	0.03264	0.09792
E.E. team	0.06528	0.26112
Accidents		
Spill onto worker		728.5715
Broken Hose		18.2143
Accidental spray of adult		0.1266
Accidental spray of child		0.1899
Spill into water--200 gallons into pond		3.5773

Table F3-16—Kerosene doses

Exposure scenario	Dose (mg/kg/day) Typical	Worst case
Public		
Dermal		
Vegetation contact	0.00026	0.00052
Dermal & inhalation drift	0.00346	0.02180
Dietary		
Water	0.00024	0.00152
Fish	0.00078	0.00495
Meat	0.00013	0.00094
Peas or Beans	0.00188	0.00976
Berries	0.00094	0.00510
Cumulative		
Fisherman	0.00128	0.00699
Hunter	0.00157	0.00808
Workers		
Pilot	0.00066	0.00389
Mixer/loader	0.00147	0.01187
Observer	0.00346	0.02180
Card checker	0.00922	0.02822
E.E. team	0.01843	0.07526
Accidents		
Spill onto worker		728.5715
Broken Hose		5.2500
Accidental Spray of Adult		0.0365
Accidental spray of child		0.0547
Spill into water--200 gallons into pond		1.0311

Table F3-17—Petroleum distillate doses

Exposure scenario	Dose (mg/kg/day) Typical	Worst case
Public		
Dermal		
Vegetation contact	0.00116	0.00234
Dermal & inhalation drift	0.01570	0.09745
Dietary		
Water	0.00109	0.00680
Fish	0.00355	0.02211
Meat	0.00060	0.00420
Peas or Beans	0.00853	0.04361
Berries	0.00426	0.02278
Cumulative		
Fisherman	0.00580	0.03125
Hunter	0.00712	0.03612
Workers		
Pilot	0.00298	0.01740
Mixer/loader	0.00667	0.05303
Observer	0.01570	0.09745
Card checker	0.04186	0.12614
E.E. team	0.08371	0.33638
Accidents		
Spill onto worker		728.5715
Broken hose		23.4643
Accidental spray of adult		0.1631
Accidental spray of child		0.2447
Spill into water--200 gallons into pond		4.6084

Table F3-18—Bacillus thuringiensis doses

Exposure scenario	Dose (mg/kg/day) Typical	Worst case
Public		
Dermal		
Vegetation contact	--	--
Dermal & inhalation drift	0.00028	0.00075
Dietary		
Water	0.00165	0.00685
Fish	--	--
Meat	--	--
Peas or Beans	0.01291	0.04381
Berries	0.00645	0.02288
Cumulative		
Fisherman	0.00165	0.00685
Hunter	0.00811	0.02973
Workers		
Pilot	0.00012	0.00023
Mixer/loader	0.00017	0.00037
Observer	0.00028	0.00075
Card checker	--	--
E.E. team	--	--
Accidents		
Spill onto worker		--
Broken hose		--
Accidental spray of adult		--
Accidental spray of child		--
Spill into water--200 gallons into pond		4.6295

less than assumed in this analysis. Penetration through clothing was assumed to be 30 percent as great as through bare skin, based on work by Newton and Norris (1981) on phenoxy herbicides.

Dermal doses to workers from accidental spills were calculated assuming that one-half liter of insecticide concentrate (or mix for acephate, which is used as a powder) is retained—90 percent on the worker's clothing and 10 percent on the skin. This amount of liquid is sufficient to wet most of the worker's body.

Observers

Observers near the spray operation were assumed to receive doses through inhalation and dermal absorption.

Dermal exposures were calculated for 2 square feet of exposed skin. The dermal penetration rates and drift deposition values described previously were used.

Inhalation exposure was calculated based on air sampler data collected during the field trials by Yates et al. (1978) described earlier in the spray drift modeling section. The worker's breathing rate was assumed to be 21.7 liters per minute (1.3 cubic meters per hour), which represents an average for an adult during moderate activity (EPA, 1981, as cited in EPA, 1986). Inhaled doses were calculated assuming that spray droplets are inspired by people with the same efficiency as air samplers. One-hundred percent of the inspired droplets were assumed to be retained and absorbed. Doses were adjusted to reflect the typical and worst case number of hours a worker would be exposed.

Card Checkers and Entomology Efficacy Team Members

Card checkers and members of the entomology efficacy team may receive doses from contact with sprayed vegetation. They are not expected to receive a dose by way of inhalation exposure.

Indirect dermal exposure as a result of contact with foliage with surface residues from drift was calculated using the "unified field model" of Popendorf and Leffingwell (1982) and Popendorf (1985). This model was developed to estimate the possible doses and effects of insecticides on agricultural workers. The model takes into account the following:

- The residue on foliage at any time after application
- A crop-specific residue transfer coefficient (cm^2/hr)
- The exposure period in hours
- The dermal penetration rate for each insecticide and the body mass of a human (70 kg)

The residue transfer coefficient has been determined for a few agricultural situations. The value of 1,600 cm^2/hour for this coefficient was used in this analysis to estimate doses to card checkers and members of the entomology efficacy team that may contact treated foliage. This value, derived from data collected for grape harvesting (Popendorf, 1985), represents a relatively high exposure situation. People engaged in activities involving less foliage contact can be expected to receive doses that are considerably less. People who contact foliage after the initial application also receive reduced doses because of degradation of the insecticides.

The analysis included degradation of insecticide residues between the time of application and the time the worker entered the treated area. The number of hours exposed per day also was included in the dose estimates.

B.t. Dose Estimation

Doses from *B.t.* exposure were calculated similarly to the chemicals, with the following changes:

- The application rates of 12 and 16 BIU/acre for typical and worst case, respectively, were converted to equivalent pounds per acre assuming 7.26 BIU per pound, as for Dipel® powder. The resulting rates are 1.65 and 2.2 lb/acre, respectively.
- Dermal exposures to *B.t.* were not calculated.

- *B.t.* was assumed not to accumulate in meat or fish.

- *B.t.* was assumed not to degrade or reproduce during the period between treatment and exposure.

Conservativism Inherent in Worker Exposure Analysis

As described previously, this risk assessment estimates two separate dose levels for each category of worker in routine operations—a typical dose and a worst case dose. The typical dose is an estimate of the average dose a worker may receive on a typical day during normal treatment operations. The typical dose is based on combining average nominal doses from field studies with scenario conditions that are typical for Forest Service operations in the Pacific Northwest. However, the typical dose estimates are higher than those that would occur in actual operations. The doses calculated here are based on field study doses of applicators who wore no special protective clothing or devices. In many of the proposed Forest Service operations, workers will probably wear protective gear.

The worst case estimates of worker doses in routine operations are high for two reasons. First, the nominal dose levels from the field studies used for extrapolation are not the average doses seen but the dose at the upper limit of the 95-percent confidence interval. This means that there is only 1 chance in 40 that a worker in the same field operation under the same conditions of terrain, weather, and equipment would receive a dose higher than the specified dose. Second, when this upper limit dose is combined with the assumptions of highest application rate for dose extrapolation, extremely high doses are estimated that are unlikely to occur under true operational conditions. The probability of these events occurring at the same time is low.

In addition, the field study may also take into account normal operational errors, such as errors of measurement during manufacturing and formulation, errors of measurement during field mixing, and excessive swath overlap during application.

Exposures to Members of the Public

Insecticide Residues

Residues on Plants. Insecticide residues on plants on treated sites were estimated based on factors reported by Hoerger and Kenaga (1972). These factors were derived from a large number of studies, and they allow prediction of residues in parts per million (ppm) based on the application rate in pounds per acre. After the Hoerger and Kenaga (1972) study, the plants were classified into broad groups based on vegetative yield, surface-to-mass ratio, and plant interception factors. The residues estimated for each type of plant are intended to represent realistic, yet relatively high, estimates.

Offsite plant residues were calculated first for grasses, based on the spray drift data discussed in the previous section, and by using a regression equation given in Yates et al. (1978) to relate spray deposition on young wheat plants to that on sampling devices. The deposition was then estimated for other plant groups, including berries and legumes (peas or beans), by using the same relative factors given by Hoerger and Kenaga (1972), assuming that deposition on young wheat was approximately the same as deposition on range grass.

Doses were calculated for accidental exposure assuming legumes received direct spray at the worst case application rate.

Insecticide residues on plant surfaces decline over time as a result of absorption by the plant, degradation, volatilization, and washing by rainfall. After insecticide sprays dry on plant surfaces, they cannot be completely rubbed off because they bind to the plant surface materials. Consequently, persons entering a treated area a short time after spraying are likely to receive dermal doses much smaller than the conservative doses calculated in this analysis. Doses to members of the public assume no degradation occurs.

Residues in Fish. Typical oral doses from eating fish were calculated assuming that the fish is taken from a body of water (pond) 2 feet deep, receiving drift at 500 feet downwind of a sprayed area. The fish was assumed to have residues resulting from equilibration with the water at a bioconcentration factor of 37 for malathion (American Cyanamid, 1986), 140 for carbaryl (Verschueren, 1983), 13 for diesel oil and kerosene, and 10 for acephate. Worst case exposures were estimated using high application rates and drift 100 feet offsite.

Residues in Game Animals. Insecticide residues were calculated for a 150-pound deer. The entire body surface area of the animal was assumed to be exposed to spray drift. Forty percent of the body surface was assumed to contact vegetation and thereby gain an additional average dermal residue level equal to that on the vegetation. Penetration of the insecticides through animal skin was assumed to be the same as through human skin.

The deer was assumed to get an oral dose both by grooming and in its diet. The dose from grooming was assumed to amount to 29 percent of the nonabsorbed dermal dose. The deer diet was assumed to consist of 2.45 kilograms of forage plants and 4 liters of water per day, both containing the insecticide.

The concentration of insecticide in game meat was calculated by summing the animal's doses from both the dermal and oral routes of exposure and by assuming that 10 percent of that total dose was retained in the meat of the animal. This is similar to the method used in the exposure analysis of USDA (1984).

Insecticide and B.t. Residues in Water. Doses were calculated for humans drinking contaminated water from several contaminated sources. A shallow (2-feet deep) source was assumed to receive drift at 500 feet downwind of the sprayed area. No degradation or adsorption to sediments was assumed to occur before drinking 2 liters. The concentrations in the water were calculated as simple dilutions. For worst case exposures, the high application rates were used and the body of water was assumed to be 100 feet offsite. The actual residues in water would be less under more favorable spray conditions, at greater distances, or with deeper water bodies. Dilution or degradation also would decrease residues.

Accidental drinking water exposure also was calculated by dilution for a spill from an aircraft load of 200 gallons into a 1-acre pond.

An example calculation for acephate concentration in water is given below. The concentration in a 24-inch (0.61 meters) deep body of water per pound applied per acre at 500 feet from the sprayed area is as follows:

$$214 \text{ g/ha} \times (1{,}000 \text{ mg/g})/(10{,}000 \text{ m}^2/\text{ha}) \times 1/0.61 \text{ m} \times \text{m}^3/1{,}000 \text{ L} = 0.035 \text{ mg/L or ppm}$$

The concentration of acephate is adjusted for the typical pounds per acre applied:

$$0.035 \text{ ppm} \times 0.5 = 0.018 \text{ ppm}$$

The concentration in the fish is based on the bioconcentration factor of acephate (10x):

$$0.018 \text{ ppm} \times 10 = 0.18 \text{ ppm or mg/kg}$$

The dose to a 70-kg human based on consumption of 0.5 kg of fish is:

$$\frac{(0.18 \text{ mg/kg} \times 0.5 \text{ kg})}{70 \text{ kg}} = 0.0013 \text{ mg/kg}$$

Dermal Exposures

Dermal doses resulting from incidental contact with foliage, represented in the scenarios for vegetation contact by the hiker, were estimated by another method. Lavy et al. (1980) measured the level of 2,4,5-T herbicide on cloth patch samplers attached to a person who walked through a treated forest area. The residues were less than the detection limit of 0.01 mg per 100 cm² patch, but in this analysis a conservative assumption was made that the residues were at the detection limit. The area of clothing contacting foliage was assumed to be 40 percent of the total human surface area, and 10 percent of the total area was assumed to be bare skin contacting foliage. The same dermal penetration rates discussed previously were applied to bare skin, but the

penetration through clothing was assumed to be 30 percent over a 6-hour period, based on work by Newton and Norris (1981).

Dermal exposures were estimated for a 70-kg adult wearing short sleeves and trousers, assuming that 2 square feet of skin is covered with insecticide at the full application rate or drift deposition rate. In fact, this procedure is likely to further overestimate exposures because spray droplets, depending on their size and the wind velocity, tend to be carried around obstructions rather than landing on their surface (see Golovin and Putnam, 1962). Very small droplets, typical of ULV sprays, are the most likely to be carried around obstructions.

Dermal exposures for accidents were calculated assuming an adult is directly sprayed at the maximum application rate and that 2 square feet of skin are uncovered. Calculations were also done for a child weighing 20 kilograms. The dose to the child was adjusted relative to the adult using the body surface area ratio and body weight ratio.

Inhalation Exposures

Exposures by way of inhalation of insecticide vapors or droplets were calculated for members of the public based on the results of studies by Yates et al. (1978) described previously under spray drift modeling. Doses were calculated assuming a person respires at a rate of 1.3 m^3 of air/hour and is exposed for 2 hours.

Oral Exposures

All oral exposures were calculated assuming that no degradation occurs between spraying and eating or drinking. Label directions require preharvest waiting periods for many crops, so the exposures calculated here apply only if the label is ignored. Insecticide doses to individuals from ingestion of plants were calculated assuming that they eat 500 grams (1.1 pounds) of contaminated berries or legumes at 500 and 100 feet offsite. Ingestion of fish or deer assumes 0.5 kg are eaten per day. It is assumed an adult drinks 2 liters of water daily.

Cumulative Exposures

Cumulative exposures were calculated for members of the public who may receive exposures from a number of different pathways. Cumulative exposures were calculated for fishermen assuming they receive doses from drinking 2 liters of water, eating 0.5 kg of fish, and having incidental contact with sprayed vegetation. Cumulative exposures were calculated for hunters assuming they receive doses from drinking 2 liters of water, eating 0.5 kg of deer meat, eating 0.5 kilograms of berries, and contacting sprayed vegetation.

Exposure From Consumption of Runoff-Contaminated Water

Humans may be directly exposed to pesticides by consumption of contaminated water. Pesticides are primarily transported into surface waters via runoff from treated areas that flows into streams and lakes.

The Crow Creek Reservoir of The Dalles Watershed Management Unit, located in the northeast section of the Mt. Hood Forest Service Region, receives runoff from surrounding forested areas that may be contaminated as a result of pesticide applications in the watershed. All water in the Crow Creek Reservoir is allocated to the city of The Dalles, with the exception of 2 acres of irrigated land (Toll, 1988), and water is piped directly from the outlet of the reservoir to a water treatment facility.

Humans are exposed to pesticides if they drink water that has been contaminated. Worst case pesticide concentrations in reservoir water were estimated in the runoff study and are presented in table F3-6. If a 70-kg person (H_w) is assumed to drink 2 liters of water per day (H_c), the dose of each pesticide to humans can be calculated using the following equation:

$$H_d = (H_c)(C_{water})/(H_w)$$

where:

H_d = Dose for humans (mg/kg/day)
H_c = Human consumption rate of water (L/day)

C_{water} = Concentration in the water (mg/L)
H_w = Body weight (kg)

The doses calculated for consumption of water contaminated by runoff are summarized in table F3-19.

Human Exposure from Consumption of Crops Irrigated with Contaminated Water

Humans are exposed to insecticides if they eat crops that have been grown with contaminated irrigation water. Assuming that the insecticide is distributed uniformly throughout plant parts, and is not degraded by cooking or other forms of food preparation, daily human doses are estimated as:

$$H_d = (H_c)(C_{plant})/(H_w)$$

where:

H_d = Dose for humans (mg/kg/day)
H_c = Human consumption rate of vegetables (kg/day)
C_{plant} = Concentration in the plant (mg/kg)
H_w = Body weight (kg)

Doses from consumption of crops irrigated with contaminated water are summarized in table F3-20.

Conservatism Inherent in Public Exposure Analysis

The doses estimated for members of the general public are overestimates for a number of reasons. The smaller spray particles in offsite drift tend to move around rather than land on curved surfaces and therefore would have less of a tendency to adhere to a human's body. Second, the insecticide is not assumed to bind with any material, such as vegetation, so as to become biologically unavailable to humans. This would be an important factor in diminishing doses that may occur from any activity involving contact with treated vegetation.

The routine-worst case dose levels to the public can be considered the highest possible doses for routine spray operations because the doses are calculated in scenarios that combine unlikely factors and events, including highest application rate and smallest buffer zone. No member of the public should get a dose that is any higher than the doses estimated in the routine-worst case scenarios except in the case of an accident.

Estimation of Lifetime Doses to Workers and the Public

Doses used in the cancer risk analysis were derived by combining available information on the number of days per year an individual worker may spray an insecticide using a particular application method and estimates of the expected daily dose and the number of years of employment. Expected daily doses were calculated assuming that the worst case dose is experienced 10 percent of the time and the realistic dose 90 percent of the time, in all routine scenarios. Workers are assumed to be employed in pesticide application for 30 years. Average numbers of exposures per lifetime were used with expected daily doses for each scenario to derive realistic lifetime doses. Extreme lifetime doses were derived by multiplying expected daily dose levels estimated in worker scenarios by estimates of the highest number of days a worker is likely to be engaged in the particular type of application method.

Lifetime exposures to the public for the insecticides were derived by assuming 10 exposures per lifetime in each of the public exposure scenarios. Cancer risks for accidents were based on a single exposure in a lifetime.

Table F3-19—Doses from consumption of runoff-contaminated water

Insecticide	Subarea	Dose (mg/kg/day)
Acephate	A	0.000711
	B	0.000649
	C	0.000711
	Reservoir	0.000103
Malathion	A	0.000466
	B	0.000626
	C	0.000991
	Reservoir	0.000104
Carbaryl	A	0.00786
	B	0.00729
	C	0.00671
	Reservoir	0.00111

Table F3-20—Doses from consumption of crops irrigated with contaminated water

Insecticide	Dose (mg/kg/day)
Acephate	0.000277
Carbaryl	0.000178
Malathion	0.00126
Diesel oil	0.00150
Kerosene	0.00043

Wildlife Exposures

Representative Wildlife Species

Wildlife exposures were calculated for a group of wildlife species representative of those typically found in areas supporting forest vegetation in the Pacific Northwest. These species represent a range of phylogenetic classes, body sizes, and diets. The methodology used to determine the exposures is the same as that used in the environmental impact statements prepared by the U.S. Department of Justice, Drug Enforcement Administration, on the eradication of cannabis with herbicides (DEA, 1985, 1986), and the environmental impact statement prepared by the U.S. Department of the Interior, Bureau of Land Management, on the control of noxious weeds with herbicides (BLM, 1987). Table F3-21 lists the representative wildlife species and gives the various biological parameters used for each species in the exposure analysis. Table F3-22 lists the diet of each representative species.

Wildlife Exposure Estimates

Realistic and extreme acute exposure estimates were made for each representative species for each of the three major exposure routes: inhalation, dermal, and ingestion. Because the insecticides degrade relatively rapidly and sites are normally treated once per year, no analysis of chronic wildlife dosing was done. Because the insecticides show no tendency to bioaccumulate, as discussed in Attachment F-A, long-term persistence in food chains and subsequent toxic effects were not considered a problem and were not examined in the risk analysis.

Insecticide doses for the representative species were calculated using conservative, simplified assumptions concerning routine application operations that give *realistic* dose estimates and higher (*extreme*) dose estimates in which animals are directly sprayed. Exposures for realistic and extreme cases were based on the typical and maximum insecticide application rates.

For realistic doses, dermal exposures were based on the insecticide residue levels likely to be found on vegetation leaf surfaces because the animals are assumed to seek cover during a spraying operation. Extreme dose levels were estimated by assuming that animals do not seek cover and thus receive the full insecticide application rate on their entire body surface.

The dermal penetration rates used in the human exposure analysis were used to determine mammalian wildlife dermal penetration (that is, the amount of chemical that penetrates the animal's skin). In both realistic and extreme exposures, mammals are assumed to receive an oral dose from grooming their fur, and birds are assumed to receive an oral dose from preening their feathers. This amount is subtracted from the amount they would receive as a dermal exposure through their skin.

Realistic ingestion doses were assumed to come from animals eating a specified percentage of their daily food intake in contaminated items based on their body size. That is, the percentage of contaminated food intake decreases as body size increases because larger animals are assumed to be more far-ranging in obtaining food and would therefore be more likely to obtain some part of their diet away from the sprayed area. In the extreme case, the animals are assumed to feed entirely on contaminated food items.

Inhalation exposures are assumed to come from a hypothetical amount of insecticide droplets forming a "cloud" that moves slowly offsite.

The total systemic dose to each animal was calculated as the sum of the estimated doses received by way of dermal, ingestion, and inhalation routes. Tables F4-16 to F4-20 in the wildlife risk analysis in section F4 give the total realistic and extreme dose estimates for the representative species.

Exposure Calculations

Inhalation Exposures. Wildlife inhalation exposures were assumed to come from animals breathing in insecticide spray droplets of respirable size (30 microns in diameter or less) as a hypothetical "cloud" of those droplets moves slowly offsite. The cloud is assumed to be dispersed within the first 10 m above ground level on a 202.5 ha (500-acre) site, 1,423 m on a side, and to consist of respirable droplets that constitute 10 percent of the total applied insecticide by volume. Based on these assumptions, the airborne concentration is

Table F3-21—Representative wildlife and domestic species and associated biological parameters

Representative niche	Representative species	Body weight (grams)	Daily food intake (grams)	Percent of food contaminated in realistic case	Body surface area (cm^2)	Body surface contacting vegetation (percent)	Percent of body groomed	Inhalation volume (L/min)
Insectivorous birds	Flicker	75	15	42	178	57	49	0.038
Granivorous birds	Dove	100	11	40	216	51	45	0.048
Omnivorous birds	Jay	70	14	43	170	58	50	0.037
Piscivorous birds	Kingfisher	250	50	33	398	36	35	0.098
Carnivorous birds	Owl	100	20	40	216	51	45	0.048
Small omnivorous mammals	Mouse	20	6	55	74	93	72	0.017
Medium herbivorous mammals	Rabbit	1,350	110	24	1,224	19	21	0.480
Large herbivorous mammals	Deer	68,000	2,500	11	16,722	4	7	11.1
Carnivorous mammals	Fox	5,670	475	18	3,189	11	14	1.52
Insectivorous amphibians	Toad	22	5	54	79	90	0	0.007
Carnivorous reptiles	Snake	40	22	48	117	72	0	0.00334

Table F3-21 (continued)—Representative wildlife and domestic species and associated biological parameters

Representative niche	Representative species	Body weight (grams)	Daily food intake (grams)	Percent of food contaminated in realistic case	Body surface area (cm^2)	Body surface contacting vegetation (percent)	Percent of body groomed	Inhalation volume (L/min)
Domestic animals	Cattle	453,590	12,000	7	59,292	2	4	50.6
	Chicken	2,000	300	22	1,591	16	19	0.484
	Dog	13,000	NA	NA	5,715	8	11	3.06

NA = Not applicable or not available.

Table F3-22—Representative wildlife species diet items[a]

Representative species	Water	Grass	Forage	Seeds	Insects	Berries	Mouse	Toad	Fish
Birds									
Flicker	0.02	0	0	0	15	0	0	0	0
Mourning dove	0.05	0	0	11	0	0	0	0	0
Jay	0.05	0	0	5	5	4	0	0	0
Kingfisher	0.08	0	0	0	0	0	0	0	50
Screech owl	0.05	0	0	0	0	0	20	0	0
Mammals									
Mouse	0.05	0	1	2	3	0	0	0	0
Rabbit	0.05	110	0	0	0	0	0	0	0
Deer	1.5	500	2,000	0	0	0			
Fox	0.8	0	0	0	0	175	300	0	0
Amphibian									
Toad	0.05	0	0	0	5	0	0	0	0
Reptile									
Snake	0.01	0	0	0	0	0	0	22	0
Domestic animals									
Cow	58	12,000	0	0	0	0	0	0	0
Chicken	0.10	0	0	300	0	0	0	0	0
Dog	0.50	0	0	0	0	0	0	0	0

[a]Consumption is in liters for water and in grams for all other items.

0.002242 mg/L for each 1.12 kg/ha (1 lb/acre) applied. The cloud moves offsite at 0.9 m/sec (2 mph) and exposes animals on the downwind edge for 26.4 minutes in the realistic case. The wind is assumed to be 0.45 m/sec (1 mph) in the extreme case so that animals are exposed for 52.8 minutes. The nominal exposure was multiplied by the insecticide application rate and then by each animal's breathing rate. Their breathing rate in liters per minute is based on the following equations:

Birds: $$LPM = \frac{284 \times (BWT/1000)^{0.77}}{1,000}$$

Mammals: $$LPM = \frac{379 \times (BWT/1000)^{0.80}}{1,000}$$

Reptiles: LPM = 0.00334

Amphibians: LPM = 0.007

where:

LPM = the animal's breathing rate in liters per minute

BWT = the animal's body weight in grams

The equations for birds and mammals were taken from Lasiewski and Calder (1971). The reptile value is from a Gordon et al. (1968) study on the collared lizard. The breathing rate for amphibians was from Hutchinson et al. (1968). As anticipated, the animal modeling results showed inhalation exposures to be only a small fraction of each species' total dose.

Dermal Doses. Dermal doses are assumed to come from two sources: (1) directly from insecticide spray at the deposition rate that should occur on vegetation leaf surfaces in the realistic case and at the insecticide application rate in the extreme case, and (2) indirectly by contact with contaminated vegetation.

Fur, feathers, and scales afford varying degrees of protection against dermal exposure; by preventing the chemical from reaching the animal's skin, they may instead allow the chemical to dry or to be rubbed off in their movements. For this reason, the dermal penetration rate for each insecticide for mammals was adjusted for three other animal classes—birds, reptiles, and amphibians—using reasonable assumptions for the differences between the classes. Dermal penetration factors were multiplied by the mammalian penetration rate as follows: (1) birds, 0.75; (2) reptiles, 0.15; and (3) amphibians, 5. The amphibian factor is high because the moist, glandular skin of the amphibian serves to a large extent as a respiratory organ and is much more permeable than the skin of the other animal classes [an average of 30 percent (5 to 93 percent) of body weight in water moves through skin in 24 hours according to Moore (1964)].

Wildlife may receive indirect dermal exposure from moving through contaminated vegetation by transferring pesticide from the vegetation to their body surface. The amount transferred would depend on (1) the density of the vegetation, (2) the animal's body size in relation to the height of the vegetation, and (3) the amount of movement of the animal.

To simplify the analysis, it was assumed that a certain percentage of the animal's total body surface received insecticide at the same level as the direct dermal exposure (either the level on leaf surfaces in the realistic case or at the application rate in the extreme case). That percentage was based on the animal's body size and a movement factor (MVF) to adjust for the taxonomic class. (Mammals, for example, are expected to move more than amphibians.) The animal's total body surface area was assumed to be a function of its weight according to the following formula (Kendeigh, 1970; Schmidt-Nielsen, 1972):

$BSA = 10 \times (BWT)^{0.667}$

where:

BSA = the animal's body surface area in cm^2

BWT = the animal's body weight in grams

The animal's vegetation contact percent (VCP) is based on its body weight in grams (BWT) according to the following formula:

$VCP = 2.89\ (BWT)^{-0.3775}$

The class adjustment factors (MVF's) for differing movement are as follows: (1) birds, 0.8; (2) mammals, 1; (3) reptiles, 0.3; and (4) amphibians, 0.4. The indirect dermal dose (IND) is then calculated using the direct dermal dose (DDD):

$IND = DDD + (DDD \times VCP \times MVF)$

Mammals and birds groom themselves regularly and may receive an ingestion dose if their fur or feathers are contaminated. The percent of their body surface groomed (PBG) was assumed to be a decreasing function of their body size according to the following formula:

$PBG = 1.72\ (BWT)^{-0.29}$

No grooming was assumed for reptiles and amphibians. The oral dose for mammals and birds from grooming was subtracted from the amount of insecticide that would contribute to the animal's dermal dose.

Ingestion Doses. Each representative species was assumed to feed on contaminated food items according to a specified diet and to drink a specified amount of water. These dietary amounts are listed in table F3-22. Diets may vary from season to season and across the species range; the diet items and amounts were chosen to be a reasonable representation of what an individual animal might consume on a certain day. The diet items—grass, forage vegetation, seeds, insects, and berries—are assumed to have the following contamination levels in ppm, based on field studies by Hoerger and Kenaga (1972) for a 1-lb/acre application rate:

	Realistic	Extreme
	------------ ppm	------------
Grass	1.665	92
Forage	0.439	33
Seeds	0.040	3.2
Insects	0.0627	4.8
Berries	0.0199	1.6

Water is assumed to be drunk in the realistic case from a stream offsite that reaches a concentration of 0.001267 ppm per pound of insecticide applied per acre. In the extreme case, water reaches a concentration of 0.0068 ppm. Predators that feed on mice or toads are assumed to receive the total body burden that each of these prey species has received through the three exposure routes described above as a result of the insecticide spraying operation. Predators that feed on fish (piscivores) are assumed to receive residue levels based on the concentration in the water. In the realistic exposures, each species is assumed to consume a percentage of its daily intake in contaminated food items, depending on its body size. The percentages of food contaminated (PFC) are based on the following formula:

$PFC = 100 \times (1/(BWT)^{.2}$

In the extreme case, each species' entire daily food intake is assumed to consist of insecticide-contaminated items.

Aquatic Species Exposure Analysis

Representative species typical of aquatic habitats in the U.S. Forest Service Region 6 were used to estimate risk to aquatic organisms. These species are listed in table F3-23. These organisms were assumed to be exposed to insecticide and petroleum distillate residues by immersion in bodies of water.

Typical and maximum estimated environmental concentration (EEC's) resulting from spray drift of each insecticide were calculated for bodies of water with depths of 2, 6, 12, and 24 inches (5.08, 15.24, 30.48, and 60.96 cm). The EEC's are given in table F3-24. EEC's also were calculated for a spill of a 200-gallon load of mixture into a 1-acre pond and for direct spraying of a pond at the full application rate and are summarized in table F3-25. Risk to aquatic species from these EEC's is presented in section F4.

Table F3-23—Representative aquatic species used in the analysis

Common name	Scientific name
Rainbow trout	*Salmo gairdnerii*
Brook trout	*Salveliuus fontinalis*
Cutthroat trout	*Salmo clarkii*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomieui*
Bluegill	*Lepomis macrochirus*
Yellow perch	*Perca flavescens*
Water flea	*Daphnia* sp.
Stonefly	*Plecoptera* sp.
Scud	*Gammarus* sp.

Table F3-24—Estimated environmental concentrations (EEC's) of the chemicals in water resulting from spray drift

Chemical	Depth of water (inches)	EEC (mg/L or ppm)	
		Typical	Maximum
Acephate	2	0.2096	0.6510
	6	0.06985	0.2169
	12	0.03493	0.1084
	24	0.01746	0.05425
Carbaryl	2	0.4191	1.302
	6	0.1397	0.4338
	12	0.06986	0.2169
	24	0.03493	0.1085
Malathion	2	0.3772	1.302
	6	0.1257	0.4338
	12	0.06287	0.2169
	24	0.03144	0.1085
Petroleum distillates	2	0.4569	2.850
	6	0.1523	0.9501
	12	0.07614	0.4751
	24	0.03807	0.2375

Table F3-25—Estimated environmental concentrations (EEC's) of the chemicals in water resulting from accidents

Chemical	EEC (mg/L or ppm)	
	200-gallon spill	Direct spray
Acephate	36.77	0.0919
Carbaryl	73.53	0.1838
Malathion	73.53	0.1838
Petroleum distillates	161.0	0.4026

Section F4

Risk Analysis

This section describes the potential risks to human health, terrestrial wildlife, and aquatic organisms from the proposed spruce budworm suppression program. Risks are evaluated by comparing estimated insecticide exposures to toxicity levels found in laboratory studies. The first subsection describes the methods used to evaluate human health risks. The second subsection evaluates the risks of general systemic and reproductive effects, which include acute toxic effects, chronic systemic effects, fetotoxic, maternal toxic, and developmental (teratogenic) effects. The third subsection evaluates the risks the insecticides present for producing carcinogenic and mutagenic effects in the population at risk. The fourth subsection describes related human health risks, including synergistic effects, effects on sensitive individuals, the effects of inert ingredients, and cumulative effects. The fifth and sixth subsections describe risks to wildlife and aquatic species, respectively. All judgments about risk are discussed in light of the probabilities of the estimated exposures actually occurring.

For this section, because there are numerous tables that interrupt the flow of the text, all tables have been placed at the end of this section.

Methods of Evaluating Human Health Risks

Health risks to humans who may be exposed to the insecticides were quantified by comparing the doses estimated in the exposure scenarios presented in section F3 with the results of toxicity tests on laboratory animals listed in table F4-1 and described in section F2.

For the analysis of the risk of threshold effects, margins of safety (MOS's) are computed in this analysis by dividing a NOEL from an animal study by an estimated human dose. For example, an MOS of 100 means the laboratory-determined level is 100 times higher than the estimated dose. The MOS is used to account for the uncertainty in extrapolating from a dose that produces no observed effects in laboratory animals to a dose that should produce no adverse effects in exposed humans. An uncertainty factor of 10 typically has been used to estimate safe levels in humans from experimental studies when valid human studies have been conducted and no indication of carcinogenicity exists. An uncertainty factor of 100 is used when few or no human studies have been conducted but valid long-term animal studies are available. When very limited toxicological data are available, a safety factor of 1,000 or greater could be used to estimate acceptable human exposure. Although the computed MOS's correspond with the uncertainty factors that EPA uses to determine Reference Doses (RfD's), they are applicable only to this risk assessment. Also, a margin of safety does not always mean that the dose is safe. An MOS of three, for example, could represent a risk of toxic effects for repeated exposures.

For doses that are not likely to occur more than once, such as those received by workers accidentally spilling spray mix on their upper body, a dose estimate that exceeds the laboratory test animal NOEL does not necessarily lead to the conclusion that there will be toxic effects. All the NOEL's in this risk analysis are based on (or take into account) long-term exposure. Estimated doses that exceed the NOEL are compared to the insecticide's acute oral LD_{50} so that a judgment can be made about the risk of fatalities.

The larger the margin of safety (the smaller the estimated human dose compared to the animal NOEL), the lower the risk to human health. As the estimated dose to humans approaches the animal NOEL (as the MOS approaches one), the risk to humans increases. When an estimated dose exceeds a NOEL (giving an MOS of less than one), the ratio is reversed (the dose is divided by the NOEL) to indicate how high the estimated dose is above the laboratory toxicity level and a minus sign is attached to indicate that the dose exceeds the NOEL. A ratio of -3, for example, means that the estimated dose is three times the laboratory-determined no-effect level.

In general, when repeated doses to humans approach the animal NOEL (the MOS is less than 10), there is some possibility of harmful effects. When the MOS is less than 100, but greater than 10, sensitive individuals may be at risk. Conversely, when the human dose is small, compared with the animal NOEL

(giving an MOS greater than 100), the risk to humans can be judged to be very low. Comparing one-time or once-per-year doses (such as those experienced by the public) to NOEL's derived from lifetime studies tends to greatly overestimate the risk from those rare events.

Systemic effects are evaluated based on the lowest systemic NOEL found in a 2-year feeding study of dogs, rats, or mice. Reproductive effects are evaluated based on the lowest maternal, fetotoxic, or teratogenic NOEL found in a reproductive or teratology study.

Risks to human health from the use of *Bacillus thuringiensis* are evaluated based on the available evidence of toxicity of this biological pesticide in studies of exposed humans and laboratory animals. An MOS value is calculated for inhalation and oral *B.t.* exposures. However, these MOS's may not be appropriate in the case of *B.t.* because much of the rationale involving MOS is derived from known genetic differences in chemical metabolism, DNA repair, detoxification of molecules, and excretion of metabolites—none of which applies to *B.t.* Effects of *B.t.* on reproduction are not known, so no MOS for those effects could be calculated.

A worst case analysis of cancer risk is conducted for the insecticides and for diesel oil and kerosene. No information linking *B.t.* with cancer is available, so a cancer risk analysis was not done for *B.t.* The risk of cancer from the other insecticides is calculated for an individual by multiplying estimates of lifetime dose over a 70-year period by cancer potency estimates derived in the hazard analysis section (section F2). A worst case analysis also is conducted for those insecticides that have positive mutagenicity tests or those for which no data are available. The risk of these insecticides causing mutations is qualitative rather than quantitative, with a statement of the probable risk based on the available evidence of mutagenicity and carcinogenicity.

Risk of General Systemic and Reproductive Effects

Margins of safety were computed for workers and the public for routine operations (typical and worst case exposures) and accidents for the three insecticides, for diesel oil and kerosene in carbaryl applications, and for *B.t.* These MOS's are presented in tables F4-2 through F4-7. The margins of safety were computed by dividing the laboratory-determined NOEL's in table F4-1 by the doses calculated in section F3.

Risk to the Public from Routine Operations

Risk to the Public from Routine-Typical Exposures

Table F4-8 summarizes the margins of safety for the public in routine typical spraying and shows that they are greater than 100 for systemic effects for carbaryl, diesel oil, kerosene, and *B.t.* Margins of safety for reproductive effects for all chemicals also are greater than 100. These large margins of safety mean that members of the public could be repeatedly exposed to these levels and suffer no adverse effects.

MOS's for systemic effects from acephate are less than 100 for dermal and inhalation exposure to spray drift, for eating peas or beans that were directly sprayed, and for cumulative exposures for a hunter. MOS's for malathion for the same exposures are less than 100, as well as for eating berries sprayed with malathion and for cumulative exposures for a fisherman.

These results indicate that no reproductive effects are likely to result from the use of insecticides in spruce budworm suppression operations but that acephate and malathion could cause systemic effects, most likely cholinesterase inhibition, in exposed members of the public.

Risk to the Public from Routine-Worst Case Exposures

The routine-worst case scenarios described in section F3 were intended to indicate the upper bound for public exposure to insecticide applications in the Pacific Northwest. The low probability of occurrence of each event that is assumed to occur in estimating worst case exposures must be emphasized. It is extremely unlikely that anyone would receive a dose as high as those estimated here.

Margins of Safety From Routine-Worst Case Exposures. Table F4-9 indicates that MOS's for reproductive effects are greater than 100 for acephate, malathion, diesel oil, kerosene, and *B.t.* for the routine-worst case

exposures. Margins of safety for systemic effects projected under this routine-worst case scenario are greater than 100 for kerosene and *B.t.*

MOS's for systemic effects are less than 100 for exposure to drift of diesel oil and for a number of individual exposure routes, as well as cumulative exposures for fishermen and hunters, for acephate and malathion. MOS's for systemic and reproductive effects for carbaryl are less than 100 for exposure to drift, eating fish, and for the fisherman.

These results indicate that there is a greater risk of systemic effects, most likely increased levels of acetylcholinesterase inhibition, for acephate and malathion than under the typical spraying conditions and that there is some slight risk of effects from diesel oil drift exposure. There are increased risks from carbaryl for both systemic and reproductive effects, compared to typical exposures.

Risk to the Public from Use of Contaminated Water

Table F4-10 shows margins of safety for persons drinking contaminated water from runoff in The Dalles Watershed analysis. None of the MOS's are lower than 100 for any of the feeder streams. MOS's are greater than 1,000 for the reservoir itself, so there is little risk from runoff when large areas of a watershed are sprayed, even when rain occurs immediately after spraying.

Margins of safety for persons eating crops irrigated with contaminated water are given in table F4-11. MOS's are all greater than 100, indicating very low risk from this potential route of exposure.

Risk to the Public from Accidents

Table F4-12 summarizes the risk to the public from direct exposure to aerial spray, from eating food directly hit at the highest application rate, and from drinking water that has received a dump of 200 gallons of spray mix.

The extent of effects would depend upon their duration of exposure and any precautionary measures that were taken. For example, if people gathered a bushel of berries from a spray area and did not wash them but froze them and then ate them every day for a month, they might feel quite ill. However, if the food items were washed before being eaten, the oral dose would be reduced (and the margin of safety increased). Likewise, if people bathed after being in the forest (to wash off insecticide residues they may have come into contact with), dermal doses also would decrease (and margins of safety increase).

Again, it must be noted that these are one-time, rather than repeat or chronic, exposures and that comparison of these doses with the acute LD_{50}'s shows that no one is at risk of fatal effects.

Risk to Workers from Routine Operations

Tables F4-13 and F4-14 summarize the margins of safety for workers for routine-typical and routine-worst case exposures based on the systemic and reproductive NOEL's for the five chemicals.

Use of Protective Clothing

It must be emphasized that the routine worker exposures and resultant margins of safety are what could be expected in most spruce budworm suppression programs in the Pacific Northwest for workers not wearing protective clothing or equipment. All of the studies from which the routine-realistic exposures were calculated are based on workers wearing no protective clothing. The use of protective clothing, however, can substantially reduce worker doses, as shown in field studies of worker exposure, and thereby increase their margins of safety.

The calculated doses presented below were based on the assumption that workers work with bare hands and wear ordinary work clothing, such as cotton pants and short-sleeve shirts. It is common practice, however, for insecticide applicators to wear clothing that affords more protection. Typical clothing often includes long-sleeve shirts or coveralls, gloves, and hats.

Research has shown that such protective clothing can substantially reduce worker exposure. During insecticide applications to orchards, mixers reduced their exposure by 35 percent and sprayers reduced their exposure by 49 percent by wearing coveralls (Davies et al., 1982).

Risk to Workers from Routine-Typical Exposures

In the routine-typical exposures, all categories of workers applying kerosene and *B.t.* have MOS's greater than 100. This indicates that even workers chronically exposed to these substances should suffer no ill effects. For acephate and malathion, observers, card checkers and backpack sprayers had MOS's less than 100 (as shown in table F4-13). Also for malathion, mixer/loaders and Entomology Efficacy team members had MOS's less than 100, as did the Entomology Efficacy team members for diesel oil. For carbaryl, only backpack sprayers had MOS's less than 100. This means that unprotected workers who routinely receive doses this high may experience some toxic effects from applying these insecticides.

Risk to Workers from Routine-Worst Case Exposures

As shown in table F4-14, acephate, carbaryl, malathion, and diesel oil all have MOS's less than 100 for routine-worst case exposure.

The probability of workers receiving doses as high as predicted here on a daily basis is extremely low. Therefore, even if a worker felt ill for a day or so from an unusually high dose, permanent damage would be unlikely. Most of the time, workers will be receiving doses less than those predicted in the routine-worst case scenario. Sensitive individuals would be at greater risk.

Risk to Workers from Accidents

Dermal doses estimated in this analysis tend to exaggerate the amount that would actually be received because the dermal penetration rates used in the calculations assume no time factor is involved; that is, the chemicals penetrate the skin immediately. In reality, the penetration rates involve a significant time factor because they were derived from studies in laboratory animals over a period of one to several days. This means that unprotected workers who routinely receive doses this high may experience some toxic effects from applying these insecticides. Thus, workers would have to ignore their own safety and *not* wash the chemical off to receive doses as high as predicted in these accidents.

Margins of safety for worker accidents are presented in table F4-15. Workers who spill 500 mL of insecticide concentrate or spray mix on their skin may experience acute toxic effects—in particular, high levels of acetylcholinesterase inhibition—if they do not wash the chemical off. In the case of a spill of 500 mL of concentrate, the dose exceeds the LD_{50} only for carbaryl. The acephate dose is 10 percent of the LD_{50}; the malathion dose, 75 percent of the LD_{50}; the diesel oil dose, 10 percent; and the kerosene dose, 3 percent of the LD_{50}. For carbaryl and malathion in particular, this represents a clear risk of severe toxic effects if the chemical is not washed off immediately.

Workers are not likely to be affected by kerosene if they are directly sprayed, but they may be affected by diesel oil (MOS = 58). MOS's for acephate, carbaryl, and malathion are relatively low for the worker accidentally sprayed, although they do not exceed the NOEL; so risks of severe effects are not as high as in the spills of concentrate or mix on their skin.

Risk to Humans from *Bacillus thuringiensis*

Risk of Direct Effects from *B.t.*

Margins of safety for *B.t.* exposures are given in table F4-7. Risks to humans from the Forest Service use of the current formulations of *Bacillus thuringiensis* appear to be negligible. The Dipel® and Thuricide® formulations of *B.t.* are generally nontoxic to humans because they do not produce the two metabolic products alpha-exotoxin and beta-exotoxin that are known to be toxic to vertebrates.

There have been no reports of chronic health effects in workers exposed in the production of *B.t.*, although an incident involving a Dipel® suspension that splashed into a farmer's eye suggested that *B.t.* may result in eye

infection. Laboratory studies in which *B.t.* was applied directly to the eye of a rabbit showed no such infections (Sassaman, 1987).

Skin irritation has been demonstrated in rabbits treated with the Dipel® 4L formulation of *B.t.*; however, no acute, subchronic, or chronic systemic toxicity has been shown in animal studies.

Risk of Effects from *B.t.* Contaminants (Bioburden)

John Ogle of *Agriculture Canada* reports a study in which three *B.t.* formulations were tested for contamination with other microorganisms. Dipel® contained fecal streptococci at a level of 1 million to 10 million per billion international units (BIU) of *B.t.* The manufacturer, Abbott Laboratories, was alerted and implemented measures that reduced the contaminant to a level of less than 1,000 per BIU. The Canadians plan to reduce this to less than 100.

The U.S. Forest Service has submitted samples of *B.t.* to the Food and Drug Administration for contaminant testing. Results are not available at this time.

Studies in humans who were administered *B.t.* by various routes (oral, ingestion, inhalation) have indicated no adverse effects at the doses tested (Sassaman, 1987). No definitive proof has been found that current *B.t.* formulations used by the Forest Service would contribute to the overall bioburden of human disease-causing microorganisms, such as virus or streptococcus. The Forest Service has described their current evaluation of the situation as follows (USDA, 1988):

> In over 18 years of *B.t.* use, there have been no scientifically documented cases or evidence of *B.t.*-caused illness directly attributable to forestry-use situations. This long history of use and a special study on the health effects of *B.t.* spray programs conducted by the Oregon Department of Human Resource's Health Division between 1985-87 have not resulted in [the identification of] any cause and effect relationships between *B.t.* use and human illness. Thus, they appear to corroborate the apparent safety of this biological pesticide.
>
> Low levels of extraneous microorganisms do exist in *B.t.*; however, these low levels do not affect the overall safety of *B.t.* The same environmental bacteria are also present at similar levels in water, food, milk, and other dairy products. The chances of exposure to low levels of extraneous microorganisms may be greater from eating or drinking ordinary food products than from *B.t.* use in forestry.
>
> Another concern recently expressed was the possibility of enterotoxins being present in *B.t.* products. Manufacturers of *B.t.* products advise us that due to steps taken in the manufacturing process, it is unlikely that enterotoxins would be present in distributed products.
>
> A final concern has been *B.t.* contamination of food or feed. Given current information, and under forestry use conditions, the probability of *B.t.* contaminating food or food products is highly unlikely. During all the years of *B.t.* use in agriculture and forestry, no evidence has been seen that *B.t.* grows on food, produces enterotoxins, significantly increases the bioburden, or causes unacceptable contamination.
>
> Manufacturers of *B.t.* products are required by law to test each lot of *B.t.* technical material produced. Each lot is tested for pathogenicity and vertebrate toxicity. Therefore, additional testing by the Forest Service is believed unnecessary.

Thus, it appears that humans exposed to *B.t.* in spruce budworm suppression operations may be at some low level of risk from eye or skin irritation or infection but are not at risk of any systemic effects from *B.t.*

Cancer Risk

A worst case analysis for cancer was conducted for the three insecticides and for diesel oil and kerosene.

The cancer risks presented in table F4-16 were computed using the following formula:

cancer risk = cancer potency x lifetime dose

The lifetime doses for each type of exposure were computed as described in section F3. The cancer potencies used in the analysis are listed in table F4-1 and their derivation is described in the hazard analysis (section F2).

Public Cancer Risks

Results for acephate, carbaryl, malathion, diesel oil, and kerosene indicate that no member of the public is at a greater than 2.3 in 100 million risk of cancer from routine exposures. Accidental exposures resulting from a spill into a pond present a cancer of 3.8 in 10 million for acephate and 3.1 in 10 million or less for the other chemicals.

There are not sufficient data to characterize the carcinogenicity of *B.t.* in humans.

Worker Cancer Risks

Cancer risks to workers for a 30-year work life at various tasks are also presented in table F4-16. Except for accidents, workers are not at cancer risk greater than 1 in 1 million for any task or chemical. Cancer risks for worker accidents exceed 1 in 1 million for acephate and malathion spills on worker's skin (3.1 in 100,000 and 4.8 in 100,000, respectively) and for a broken hose accident involving malathion (1.0 in 10,000) or acephate (1.6 in 10,000). Accidental exposures assume the worker does not wash when the accident occurs. Normal precautions and immediate washing should reduce the actual cancer risk below 1 in 1 million.

Comparison of Cancer Risks with Other Common Risks

Table F4-17 presents cancer risks resulting from several familiar hazards and occupational risks. Motor vehicle accidents have a risk of fatality that averages 2 in 10,000 per person each year. Over a 30-year period, the cumulative risk would be 6 in 1,000. A variety of hazards that have of approximate risk of 1 in 1 million include smoking 2 cigarettes, eating 6 pounds of peanut butter, drinking 40 sodas sweetened with saccharin, or taking 1 transcontinental round trip by air. The cancer risk for a single x-ray is 7 in 1 million. Many occupational risks are greater. Working for 30 years in agriculture or construction has a risk of about 1.8 in 100, and in mining and quarrying, the risk is even greater: 3 in 100 over 30 years.

Risk of Heritable Mutations

No human studies are available that associate the insecticides in this analysis with heritable mutations. Furthermore, no risk assessments that quantify the probability of mutations from the insecticides are available in the literature or from EPA. Laboratory studies constitute the best available information on mutagenic potential. Results of the mutagenicity assays conducted on the three insecticides are summarized in section F2.

For some of the insecticides, no acceptable mutagenicity tests exist. For these insecticides, a worst case assumption is made that these insecticides have the potential to cause mutations in humans. In these cases the results of carcinogenicity tests (table F2-3 in section F2) or cancer risk assessments can be used to estimate the worst case risk for mutagenicity. The rationale for this assumption is summarized by the USDA (1985) as follows:

> Since mutagenicity and carcinogenicity both follow similar mechanistic steps (at least those that involve genetic toxicity), the calculated risk of cancer can be used as a worst case approximation of somatic cell mutation risk. The basis for this assumption is that both mutagenicity and at least primary carcinogens react with DNA to form a mutation or DNA lesion affecting a particular gene or

set of genes. The genetic lesions then require specific metabolic processes to occur, or the cells must divide to insert the lesion into the genetic code of the cell.

We believe the cancer risk provides a worst case approximation to heritable mutations for the following reasons:

1. All chemicals known to induce heritable germ cell mutation in mammals also produce cancer in mammals and almost always at a lower total dose.

2. Many chemicals that are carcinogens in rodents fail to induce heritable germ cell mutations even at the maximum tolerated dose.

3. Mammalian meiotic processes in gonadal tissue appear to be much more efficient in eliminating DNA lesions than somatic cells.

4. Human epidemiology studies of populations exposed to genotoxic carcinogens (radiation exposures in Nagasaki and Hiroshima) have demonstrated significant induction of cancer but no evidence of heritable mutations.

Malathion tested negative for mutagenicity in all but one assay conducted, and thus can be considered to pose no mutagenic risk. Carbaryl and acephate were nonmutagenic in the majority of assays conducted. Therefore, it can be assumed that their germ cell mutagenic risk is slight to negligible.

Other Possible Effects of the Insecticides

Synergistic Effects

Synergistic effects of chemicals are those that occur from exposure to two or more chemicals either simultaneously or within a relatively short period of time. For example, forestry workers exposed to the fungicide thiram have experienced skin blotching and nausea from drinking alcoholic beverages within 10 days of their thiram exposure. Synergism occurs when the combined effects of the two chemicals cannot be predicted based on the known toxic effects of the individual chemicals or when their combined effect is much greater than the sum of the effects of each agent alone. For example, a mixture of the herbicides 2,4-D and picloram has produced skin irritation in test animals while neither insecticide alone has been found to be a skin irritant. Cigarette smoke and asbestos are both known carcinogens. When inhaled in combination, they have been found to increase cancer risk eight-fold above the risk of persons exposed to asbestos who do not smoke.

Evidence of Synergistic Effects from Pesticides

Instances of chemical combinations that cause synergistic effects are relatively rare. Kociba and Mullison (1985), in describing toxicological interactions with agricultural chemicals, state the following:

> Our present scientific knowledge in toxicology indicates that an exposure to a mixture of pesticides is more likely to lead to additivity or antagonism rather than synergism when considering the toxicological effects of such a combination. To be conservative and for reasons of safety, an additive type of toxicological response is generally assumed rather than an antagonistic type of response.
>
> In the case of registered pesticides, much toxicological information is developed during the research and development of each individual pesticide. In addition to this information on individual pesticides, short-term toxicity studies are always done prior to the selling of a pesticide mixture. Should synergism unexpectedly be present in a proposed commercial mixture of two pesticides, it would be identified in such cases and would then be dealt with accordingly. In toxicological tests involving a combination of commercial pesticides, synergism has generally not been observed.

The toxic effects of the possible insecticide combinations other than the EPA-registered commercial mixtures have not been studied. Time and money normally limit toxicity testing to the first priority—the effects of the insecticides individually—and this type of information is not yet sufficient in some cases. Moreover, the combinations that could be tested are too numerous to make that toxicity testing feasible. The combinations

of interest in this risk assessment include not only combinations of two or more of the three insecticides, but also combinations of the insecticides with other chemicals, such as herbicides, that exist in the environment. Based on the limited amount of data available on pesticide combinations, it is possible—but very unlikely—that synergistic effects could occur as a result of exposure to two or more of the insecticides considered in this analysis.

Malathion, a relatively safe insecticide, has been observed to produce synergistic effects when combined with other organophosphorus insecticides. One incident of apparent poisoning from malathion in Pakistan spraymen indicates the possible synergistic effects of this pesticide (Baker et al., as cited in Doull et al., 1980). Data on specific organophosphorous pesticides that are synergistic with malathion have not been located (to date) in current literature.

Likelihood of Exposure to Two Insecticides

For several reasons, it is highly unlikely that synergistic adverse effects could result from exposure to more than one insecticide applied in separate projects. First, unlike the situation in conventional agriculture, insecticide residues in plants and soil are not expected to persist from one application to another, even for the more persistent insecticides. Also, the probability of more than one insecticide being used in any year is remote.

Second, the three insecticides are known to be rapidly excreted from the body. None of the insecticides has been found to accumulate in test animal body tissues, so exposure of an individual to two insecticides at different times would be unlikely to cause simultaneous residues in the body.

Third, public exposures to the insecticides should be low (except for accidents) and should occur only very infrequently. The probability of a larger accidental exposure to any single insecticide is extremely low. Because the probability of a member of the public receiving a large exposure is so low for one insecticide, the probability of simultaneous large exposures to two insecticides is negligible. This is because the probability of two independent events occurring simultaneously is the product of the probabilities of the individual events. For example, if the probability of a person receiving a given exposure is 1 in 1,000 for each of two insecticides, then the probability of receiving that exposure to both insecticides would be 1 in 1 million.

Risks from Insecticide Mixtures

Simultaneous exposure to more than one chemical is likely in cases where those chemicals are combined in a single spray mixture. Although most spruce budworm control projects in the Region would involve only a single insecticide, some areas would be treated with a mixture of insecticides, but only EPA-approved mixtures would be used.

The EPA guidelines for assessing the risk from exposures to chemical mixtures (EPA, 1986a) recommend using additivity models when little information exists on the toxicity of the mixture and when components of the mixture appear to induce the same toxic effect by the same mode of action. They suggest in their discussion of interactions (synergistic or antagonistic effects) of chemical mixtures that "there seems to be a consensus that for public health concerns regarding causative (toxic) agents, the additive model is more appropriate than any multiplicative model."

Table F4-18 shows margins of safety for the mixture used in spruce budworm suppression that is most likely to cause additive effects—the combination of diesel oil and kerosene used in carbaryl applications. The table indicates that, except for worst case drift exposures (systemic MOS = 76), all MOS's for systemic and reproductive effects for the public are greater than 100. Some systemic effects may be seen in worker Entomology Efficacy (EE) Team members in typical exposures and in observers, card checkers, and Entomology Efficacy Team members in worst case exposures. No workers should experience reproductive effects. Workers and members of the public may experience both systemic and reproductive effects from accidents.

Although the insecticides used for spruce budworm control are unlikely to have synergistic toxic effects, other substances occurring in the diets of exposed people may have some influence on the toxicity of the insecticides.

Effects on Sensitive Individuals

If the response of a population of test animals to varying doses of a chemical follows a normal distribution (bell-shaped curve), the hypersensitive individuals are those on the left-hand side of the curve that respond at much lower doses than the average. A safety factor of 10 has traditionally been used by regulatory agencies (NAS, 1977) to account for this intraspecies (that is, interindividual) variation. Not all sensitive individuals will be covered by an MOS of 100 because human susceptibility to toxic substances can vary two to three orders of magnitude (Calabrese, 1985). (These individuals could correspond to the very tail of the bell-shaped curve.)

Factors Affecting the Sensitivity of Individuals

Factors that may affect individual susceptibility to toxic substances include diet, age, heredity, preexisting diseases, and life style (Calabrese, 1978). These factors have been studied in detail for very few cases, and their significance in controlling the toxicity of the proposed insecticides is unknown. However, enough data have been collected on other chemicals to show that these factors can be important.

Elements of the diet known to affect toxicity include vitamins and minerals (Calabrese and Dorsey, 1984). For example, the mineral selenium can prevent the destruction of blood-forming tissues that results from chronic heavy exposure to benzene. Large doses of vitamin C have also been shown to protect animals and humans from the toxic effects of chronic benzene exposure. Vitamin A seems to have a preventative effect on cancer induced by chemicals such as benzo(a)pyrene (found in cigarette and wood smoke) and DMBA. This effect has been seen in laboratory animals and human epidemiological studies. The food additives BHT and BHA also may be active in preventing the carcinogenicity of benzo(a)pyrene. Various levels of the B vitamin riboflavin have also been tested with mixed results. Vitamin C has been shown to prevent nitrites from combining with amines to form nitrosamines, and vitamin E seems to be at least as effective. These vitamins would be likely to prevent the formation of N-nitrosoatrazine and N-nitrosoglyphosate if conditions were otherwise favorable for their formation in the human stomach (Calabrese and Dorsey, 1984).

Genetic factors are also known in some cases to be important determinants of susceptibility to toxic environmental agents (Calabrese, 1984). Susceptibility to irritants and allergic sensitivity vary widely among individuals and are known to be largely dependent on genetic factors. Race has been shown to be a significant factor influencing sensitivity to irritants, and some investigations have indicated that women may be more sensitive than men (Calabrese, 1984).

A variety of human genetic conditions have been identified as possibly enhancing susceptibility to environmental agents. For example, persons with beta thalassemia may be at increased risk when exposed chronically to benzene. However, only one condition, G-6-PD deficiency, has been conclusively demonstrated to cause enhanced susceptibility to industrial pollutants. Several other genetic conditions have been shown to involve defects in the cellular mechanisms for repair of damage to DNA. Persons with these diseases share an increased sensitivity to the effects of ultraviolet light, which can cause cancer. Cells from individuals with at least one of these diseases, xeroderma pigmentosum, also are sensitive to a variety of chemical substances implicated as causative agents of human cancers (Calabrese, 1984).

Persons with other types of preexisting medical conditions may also be at increased risk of toxic effects. For example, sensitivity to chemical skin irritants can be expected to be greater for people with a variety of chronic skin ailments. Individuals who are immunosuppressed due to illness or from therapeutic treatment may be susceptible to microbial agents not known to be infectious to normal individuals. Patients with these conditions may be advised to avoid occupational exposure to irritating chemicals or *B.t.* (Shmunes, 1980, as cited in Calabrese, 1984).

Allergic Hypersensitivity

A particular form of sensitivity reaction to a foreign substance is allergic hypersensitivity. Except for contact dermatitis in delayed allergic reactions, these are responses to high molecular weight organic molecules or whole cells. None of the insecticides in the Forest Service spruce budworm suppression program is of high molecular weight, so the immediate allergic reactions and the delayed allergic reactions, except for contact dermatitis, can be ruled out as possible toxic effects. Contact dermatitis may be induced by lower molecular weight substances, such as the catechols of poison ivy, cosmetics, drugs, or antibiotics (Volk and Wheeler,

1983). Benzocaine, neomycin, formaldehyde, nickel, chromium, and thiram are all known to produce these reactions (Marzulli and Maibach, 1983).

A series of dermal sensitization studies showed no evidence that *B.t.* could induce allergic hypersensitivity (Fisher and Rosner, 1959, as cited in Sassaman, 1987).

Likelihood of Effects in Sensitive Individuals

Based on the current state of knowledge, individual susceptibility to the toxic effects of the insecticides cannot be specifically predicted. As discussed above, safety factors have traditionally been used to account for variations in susceptibility among people. The margin-of-safety approach used in this risk assessment takes into account much of the variation in human response, as discussed earlier by Calabrese (1985). As described in the introduction to this risk assessment, a safety factor of 10 is used for interspecies variation; an additional safety factor of 10 is used for within-species variation.

Thus, the normal margin of safety of 100 for both types of variation is sufficient to ensure that most people will experience no toxic effects. However, unusually sensitive individuals may experience effects even when the margin of safety is equal to or greater than 100.

Some people may develop contact dermatitis from insecticide exposure. However, the small, infrequent exposures of the public should limit the possibility of their experiencing this type of reaction.

Effects from Inert Ingredients in Insecticide Formulations

Inert ingredients are chemicals that are added to the active ingredient to prepare a pesticide formulation. Inert ingredients provide a carrier for the active ingredient that facilitates the effective application of the pesticide but that is not intended to supplement the pesticide's toxic properties.

This risk assessment characterizes human health risks by comparing estimated insecticide doses with toxicity levels found in laboratory animal studies. The estimated doses and laboratory hazard levels are based on the active ingredients of the proposed insecticides, not on the formulated products. This is reasonable because the active ingredients possess the intended pesticidal properties. However, consideration of the possible toxic properties of the remaining portion of the formulations, the inert ingredients, is also warranted as is the possibility of synergism from the combination of active and inert ingredients in the formulations.

Toxicity of the Inert Ingredients

For the toxicity of the inert ingredients alone, EPA's Office of Pesticide Programs (EPA, 1986b) has identified about 1,200 inert ingredients used in approved pesticides and has reviewed the available evidence concerning their toxicity. The data included laboratory toxicity tests, epidemiological data, and structure/activity relationships. A particular concern in reviewing the inerts was their potential for causing chronic human health effects. On completion of its review, EPA categorized the 1,200 inerts into the following four lists.

- List 1 contains about 55 inerts that have been shown to be carcinogens, developmental toxicants, neurotoxins, or potential ecological hazards that merit the highest priority for regulatory action. EPA is requesting manufacturers to replace these inerts in their formulations with less toxic chemicals.

- List 2 contains approximately 50 chemicals that have been given high priority for testing because of available toxicity data that are suggestive, but not conclusive, of possible chronic health effects or because they have structures similar to chemicals on List 1.

- List 3 contains approximately 800 chemicals that are of lower priority for testing because neither available toxicity data nor a review of their chemical structure shows evidence that would place them in List 1 or 2.

- List 4 contains about 300 chemicals that are generally recognized as safe. It includes substances such as corn oil, honey, peanut oil, and water.

Because EPA normally classifies inert ingredients as "Confidential Business Information," information on them does not have to be released to the public under the Freedom of Information Act (see also 40 CFR 1506.(a)). Nonetheless, the Forest Service requested that EPA review each of the formulations of the three insecticides proposed for use and disclose whether any of them contained inert ingredients of, or suggestive of, toxicological concern.

Kerosene, a petroleum distillate and a carbaryl inert, is on EPA's List 2. A risk analysis was performed on diesel oil, used as a carbaryl carrier, and kerosene.

Toxicity of the Formulations

With respect to the possibility of synergism in the formulated combination of active and inert ingredients, EPA generally requires only acute toxicity data on formulated products. These data also allow EPA to address concerns about the acute toxicity of the pesticide formulations' inert ingredients. However, none of the insecticide formulations proposed for use by the Forest Service have undergone chronic toxicity testing, including cancer testing, or any reproductive, developmental, or mutagenicity testing. The inert ingredients in the proposed formulated products might cause cancer or other long-term health effects. Given that little information is available on each insecticide's formulation, the possibility that the formulated product is more toxic than the active ingredient cannot be discounted entirely. EPA (1986a) suggests that, in the absence of data, additive effects should be assumed. Therefore, this analysis does not assume that the insecticides are synergistic with inert ingredients in their formulations.

Cumulative Effects

The total area of U.S. Forest Service land in Washington and Oregon is 38,000 square miles. This area makes up about one-fourth of the total land area (165,000 square miles) of those two States. In a given year, the Forest Service may treat up to approximately 1,350 square miles (850,000 acres) with insecticides for budworm suppression. The treated area would thus comprise less than 1 percent of the total land area of the two States. Moreover, the treatments would occur for the most part in the remote areas of these densely forested lands. In general, treatment units are sprayed only once in a given year, then not treated again until a number of years later. The later treatment also may be with a different insecticide.

No individual member of the public is likely to receive repeated exposures to any of the insecticides because of the remoteness of most treatment units, the widely spaced timing of repeated treatments, and the use of a variety of insecticides for different purposes. In addition, the precautions taken by the Forest Service in their treatment operations make any dose at all to the public unlikely.

Populations at Risk

The populations at risk in insecticide spraying operations in the Pacific Northwest fall into three categories: (1) workers involved in the spray operations; (2) forest users, such as hikers, hunters, and fishermen; and (3) residents of dwellings in and near the forest.

The number of workers involved in spraying operations for a typical spray year for the Forest Service is discussed in section F3. The number of forest visitors to Forest Service and BLM land is recorded as visitor days by the agencies. The Forest Service in Region 6 averages approximately 30 million total visitor days annually. The number of residents living within one-quarter of a mile of Forest Service land is 29,831, and is 50,919 within one-half of a mile.

Again, because of the remote locations of most insecticide application sites, no member of the public should be exposed during most operations.

Wildlife Risk Analysis

Wildlife species risk from spruce budworm suppression with insecticides is a function of the inherent toxicity (hazard) of each insecticide to different organisms and of the amount of each chemical (dose) those organisms may take in as a result of a spraying operation. The wildlife species risk analysis compares estimated acute exposures of representative species determined in the previous section with acute toxicity levels found in laboratory studies.

Wildlife Risk Analysis Criteria

For wildlife risks, the criteria used by EPA in ecological risk assessment (EPA, 1986c) were used to judge the absolute risks to the different representative species and the relative risks among the five chemicals. The EPA criteria call for comparison of an estimated environmental concentration (EEC) with a laboratory-determined LD_{50} or LC_{50} for the most closely related laboratory test species.

If the EEC exceeds 1/5 the LD_{50} or LC_{50} but is less than the LD_{50} or LC_{50}, EPA deems it a risk that may be mitigated by restricting use of the pesticide. EPA judges EEC's that exceed the LD_{50} or LC_{50} as significant, unacceptable risk levels. Doses below the 1/5 LD_{50} level are assumed to present a low or negligible risk. In this risk assessment, an organism's total estimated dose (rather than an EEC) is compared with the laboratory toxicity level to include exposures from all exposure routes, including oral, dermal, and inhalation.

Analysis of insecticide risk to wildlife compared estimated acute doses for the representative wildlife species with available hazard information on the most closely related species. Because the insecticides examined in this risk assessement show no tendency to bioaccumulate, long-term persistence in food chains and subsequent toxic effects, such as those that have resulted from the use of the persistent organochlorides, are not considered a problem and are not examined in the risk analysis. No analysis of chronic wildlife dosing was done because the insecticides degrade relatively rapidly and sites are normally treated only once per year.

Wildlife toxicity reference levels used to assess the risks of the insecticides are given in tables F4-19 through F4-23.

Wildlife Exposure Analysis

Tables F4-19 through F4-23 also give the total realistic and extreme dose estimates for the 14 representative wildlife species for each of the spruce budworm insecticides being evaluated for Region 6.

The wildlife risk assessment tends to overstate the risks because many of the assumptions are quite conservative. For example, no degradation of the insecticides is assumed to occur and all insecticide sprayed is assumed to be biologically available. In the extreme exposures, the entire diet of an animal is assumed to consist of contaminated items, while in the realistic case, a significant percentage of the diet is assumed to be contaminated. Dermal exposures are assumed to come both directly from insecticide spray and indirectly from brushing up against treated vegetation. Birds and mammals are assumed to receive dermal doses through their skin and from grooming. This accumulation of doses from every route undoubtedly overestimates doses, even in the realistic case. Nevertheless, when these dose estimates do exceed the EPA risk criterion, and more so when they exceed the LD_{50} for the most closely related laboratory species, there is a clear risk of adverse effects on individual animals.

B.t. Risk to Nontarget Organisms

Wildlife and aquatic species are not at risk from *B.t.* applications. Available studies indicate that *B.t.* is relatively nontoxic to all vertebrate forms. Nontarget insects are at risk. The delta-endotoxin produced by *B.t.* is toxic to larvae of lepidopteran insects (butterflies and moths), coleopterans (beetles), and to some dipterans (flies and mosquitoes). Certain species such as the cinnabar moth, which is used as a control of tansy ragwort, may be affected by *B.t.* application. Other desirable species, such as rare butterflies, also could be affected. The U.S. Fish and Wildlife Service identifies endangered and threatened species of invertebrates and the Forest Service would cooperate to mitigate the effects of *B.t.* applications on endangered or threatened lepidopterans.

Wildlife Risk Overview

In most cases, based on the available toxicity data and on the proposed application rates, the risks to wildlife from the use of the three insecticides and diesel oil and kerosene are low to negligible in the spruce budworm suppression program. The realistic dose estimates are well below the EPA risk criterion of 1/5 LD_{50} and are far below the laboratory species LD_{50} for all typical cases and for most of the species in the extreme cases. In the extreme cases, there are moderate risks to mice from acephate; to mice, toads, and snakes from carbaryl; and to rabbits from malathion.

Local populations of small mammals, small birds, amphibians, and reptiles may be adversely affected when large areas are treated; however, the reproductive capacity of these species is generally high enough to replace the few lost individuals within the next breeding cycle. Populations of larger mammals and birds and any domestic animals present are not likely to be affected at all.

The risks of the individual insecticides are discussed below. Literature references for the toxicity levels in laboratory species are given in the wildlife hazard analysis. Again, it must be noted that there are very few toxicity studies on which to base these conclusions. However, the conservatism used in estimating the wildlife doses should compensate for much of the uncertainty in the toxicity data base.

The risks to wildlife of the individual chemicals used in spruce budworm suppression can be judged by examination of tables F4-19 through F4-23.

Acephate. None of the realistic doses of acephate for any representative species exceeds the EPA risk criterion level of 1/5 the LD_{50}. The extreme dose to the mouse does exceed the EPA risk level; therefore, small mammals directly sprayed may be at risk from the use of acephate. No other wildlife or domestic species should be affected.

Carbaryl. None of the realistic wildlife doses of carbaryl exceed the EPA risk criterion of 1/5 LD_{50}. Extreme doses to mice, toads, and snakes do exceed this risk level; therefore, small mammals, amphibians, and reptiles may experience adverse effects.

Exposures from carbaryl were also calculated for bees. Onsite, adult bees will receive an estimated dose of 0.225 mg/kg, which exceeds the EPA risk criterion of 1/5 LD_{50}. The LD_{50} for bees is 10 mg/kg. At 500 feet offsite, the dose was calculated to be 0.043 mg/kg, well below the level at which a risk would be expected. Therefore, bee populations in a treated area that are directly sprayed may experience adverse effects, including mortality to some individual bees.

Malathion. Only the extreme malathion dose to the rabbit exceeds the EPA criterion, although the bird, mouse, and reptile and amphibian doses approach the 1/5 LD_{50} levels, so there is some low level of risk to wildlife from the use of malathion.

Diesel Oil and Kerosene. Wildlife exposures are far below the EPA risk levels for these two chemicals, so they present no risk to wildlife in this program.

Risk to Bird Eggs and Nestlings

To any bird eggs or nestlings exposed to the three insecticides or diesel oil and kerosene, some risk of death or injury is present. Risks would be greatest for the use of acephate and malathion, considering their possible effects on mature birds, as indicated in tables F4-19 and F4-21. The nestlings may get a dermal dose, depending on how well protected the nest is, and an oral dose, depending on the amount of residues on their food items. Bird eggs are far less likely to be affected by the insecticides because they are not likely to be left uncovered during a spray operation. The parents' body would protect the eggs from direct deposition, although a minor amount of insecticide might reach the egg by way of the feathers of either incubating parent. Diesel oil and kerosene do present some risk to bird eggs because they penetrate the shell more easily than the water-based insecticides and are relatively toxic to developing embryos. Again, the eggs are not likely to receive any appreciable amount of these chemicals because the eggs are normally protected by an incubating adult.

Aquatic Risk Analysis

The risks of adverse effects from exposure to the insecticides that drift offsite and from accidents were estimated for the representative aquatic species described previously. Acute toxicity reference values (LC_{50}'s or EC_{50}'s) used in the analysis were selected for the representative species in the aquatic hazard analysis (section F2).

In cases where no acute toxicity reference value was available for a representative species, a value was selected from those available using the value of the most closely related species. For fish species, preference was given to toxicity values of other species within the same genus or family. If no toxicity values were available for any member of that family, then the lowest value reported for any fish species was used.

To estimate the risk of adverse effects occurring, the selected toxicity reference values were compared to the typical and worst case estimated environmental concentrations of each insecticide for a body of water 2 inches, 6 inches, 1 foot, or 2 feet deep. The ratio of the EEC to the LC_{50} or EC50 is called the quotient value (Q-value). Typical EEC's were based on typical application rates and a distance of 153 meters (500 feet) from the application site to the body of water. Worst case EEC's were calculated using maximum application rates and a distance of 30.5 meters (100 feet) to a body of water. EEC's for petroleum distillates were based on the fraction of kerosene in carbaryl formulations and the amount of diesel oil used as a carrier. The Q-values were compared to the risk criteria proposed by EPA (1986c) where the risks of adverse effects to fish or invertebrates are estimated as follows:

Q-value		Risk
EEC/LC_{50}	< 0.1	No acute risk
EEC/LC_{50}	≥ 0.1 and < 0.5	Presumption of moderate risk that may be mitigated
EEC/LC_{50}	≥ 0.5	Presumption of significant risk of acute effects

Results of the Risk Analysis

Acute Toxicity

Q-values are presented in tables F4-24 through F4-27. The results of the risk analysis for aquatic species indicates that there may be adverse effects under some conditions.

Acephate. Acephate presents significant risks to some species in shallow water bodies from typical EEC's. In depths of 1 foot or more, moderate risks are present for fish, while aquatic invertebrates are still faced with significant risk. Worst case EEC's present significant risks to some species even in 2 feet of water.

Carbaryl. Typical EEC's pose a moderate risk to fish in shallow water, and a low or negligible risk at depths of 21 feet or more. Aquatic invertebrates are at significant risk in all water depths analyzed. Worst case EEC's present moderate risks to fish in 1 foot or less of water, but a low or negligible risk at 2 feet.

Malathion. Typical EEC's present moderate risks to fish in 2 feet of water, and significant risks to some species in 1 foot of water. Aquatic invertebrates are at significant risk in all cases analyzed. Worst case EEC's present significant risks, even in 2 feet of water.

Petroleum Distillates. Typical EEC's present moderate risks to fish and aquatic invertebrates in 1 or 2-feet deep bodies of water, and significant risks in shallower depths. Worst case EEC's lead to significant risks at all depths.

The acute risks to some groups of aquatic invertebrates could not be estimated for some of the chemicals because sufficient toxicity information was not available.

Chronic Toxicity

Very limited information is available on the chronic toxicity of these insecticides to aquatic species. In the absence of chronic toxicity information, the likelihood of long-term exposure to insecticide residues was evaluated. The fraction of initial insecticide residue remaining in water was calculated for 1, 2, and 3 weeks after insecticide application using insecticide degradation rates reported in the literature (see Attachment F-A). Less than 10 percent of the initial residue remains at 3 weeks for carbaryl, malathion, and petroleum distillates. Residues of approximately 73 percent of the initial acephate residue remain at 3 weeks. In streams and other lotic (flowing) waters, insecticide concentrations would quickly be reduced by dilution and transport; however, chronic exposure could occur in ponds and lakes from acephate, which degrades slowly.

Accidents

Risks to aquatic species from accidents are presented in tables F4-28 through F4-31. EEC's were calculated for a spill of a helicopter load of 758 liters (200 gallons) of insecticide mixture into a 2-foot-deep, 1-acre pond.

Fish and aquatic invertebrates would be likely to experience adverse acute effects from accidental spills of acephate, carbaryl, malathion, or petroleum distillates. Risks are high enough such that many organisms would probably be killed.

Although estimated insecticide concentrations in a pond that is accidentally directly sprayed at worst case application rates are less than those estimated for the pond spill, there would still be significant risks to some species from acephate, low to moderate risks from carbaryl, and significant risks from malathion or petroleum distillates. Invertebrates are at significant risk from direct spraying of all chemicals.

Table F4-1—Toxicity reference levels used in the analysis of human health risks

Chemical	Rat oral LD_{50} (mg/kg)	Systemic NOEL (mg/kg/day)	Reproductive developmental NOEL (mg/kg/day)	Cancer potency $(mg/kg/day)^{-1}$
Acephate	866	0.25	3	0.0093[a]
Carbaryl	270	10.0	10.0	0.135[b]
Malathion	370	0.23	25	0.00376[c]
Diesel oil	7,380	7.38	751	0.0000049
Kerosene	28,000	28	751	0.0000049
Bacillus thuringiensis				
Inhalation	---	1.4	---	---
Oral	---	500	---	---

[a]EPA, 1985.
[b]Assuming 1 percent of ingested carbaryl is converted to N-nitrosocarbaryl in the stomach (Lijinsky and Taylor, 1976).
[c]Based on data in California Department of Health Services (1980).

Table F4-2—Acephate margins of safety

Scenario	Systemic: Typical exposures	Systemic: Worst case exposures	Reproductive: Typical exposures	Reproductive: Worst case exposures
Public				
Dermal				
Vegetation contact	1,200	1,200	10,000[a]	10,000
Dermal & inhalation drift	85	28	1,000	330
Dietary				
Water	500	160	6,000	1,900
Fish	200	64	2,400	770
Meat	1,100	360	10,000	4,300
Peas or beans	64	25	770	300
Berries	130	48	1,500	580
Cumulative				
Fisherman	130	44	1,500	530
Hunter	86	33	1,000	390
Workers				
Pilot	300	150	3,600	1,900
Mixer/loader	130	51	1,600	610
Observer	85	28	1,000	330
Card checker	70	34	840	410
E.E. team	10,000	10,000	10,000	10,000
Backpack	29	6.1	350	73
Accidents				
Spill onto worker		-340[b]		-29[b]
Broken hose		-170[b]		-14[b]
Direct spray - adult		17		200
Direct spray - child		11		130
Peas or beans		15		180
Spill into water-- 200 gallons into pond		-4.2[a]		2.9

[a]Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 0.25 and a reproductive NOEL of 3.
[b]When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

Table F4-3—Carbaryl margins of safety

Scenario	Systemic: Typical exposures	Systemic: Worst case exposures	Reproductive: Typical exposures	Reproductive: Worst case exposures
Public				
Dermal				
Vegetation contact	3,200	3,200	3,200	3,200
Dermal & inhalation drift	240	76	240	76
Dietary				
Water	10,000[a]	3,200[a]	10,000	3,200
Fish	280	92	280	92
Meat	10,000	2,800	10,000	2,800
Peas or beans	1,300	500	1,300	500
Berries	2,600	960	2,600	960
Cumulative				
Fisherman	250	87	250	87
Hunter	1,100	490	1,100	490
Workers				
Pilot	830	430	830	430
Mixer/loader	370	140	370	140
Observer	240	76	240	76
Card checker	180	89	180	89
E.E. team	750	190	750	190
Backpack	79	16	79	16
Accidents				
Spill onto worker		-130[b]		-130
Broken hose		-63		-63
Direct spray - adult		45		45
Direct spray - child		30		30
Peas or beans		300		300
Spill into water - 200 gallons into pond		4.8		4.8

[a]Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 10.0 and a reproductive NOEL of 10.0.
[b]When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

Table F4-4—Malathion margins of safety

Scenario	Systemic: Typical exposures	Systemic: Worst case exposures	Reproductive: Typical exposures	Reproductive: Worst case exposures
Public				
Dermal				
Vegetation contact	730	670	10,000[a]	10,000
Dermal & inhalation drift	53	16	5,700	1,700
Dietary				
Water	250	74	10,000	8,000
Fish	890	260	3,000	870
Meat	580	170	10,000	10,000
Peas or beans	33	12	3,600	1,300
Berries	65	22	7,100	2,400
Cumulative				
Fisherman	24	7.1	2,600	780
Hunter	45	15	4,900	1,600
Workers				
Pilot	180	86	10,000	9,300
Mixer/loader	83	29	9,000	3,100
Observer	53	16	5,700	1,700
Card checker	41	18	4,500	2,000
E.E. team	77	23	8,300	2,500
Backpack	18	3.4	2,000	370
Accidents				
Spill onto worker		-1,400.0[b]		-13
Broken hose		-310		-2.8
Direct spray - adult		9.4		1,000
Direct spray - child		6.3		680
Peas or beans		6.8		740
Spill into water				
200 gallons into pond		-9.1		12

[a]Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 0.23 and a reproductive NOEL of 25.
[b]When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

Table F4-5—Diesel oil margins of safety

Scenario	Systemic		Reproductive	
	Typical exposures	Worst case exposures	Typical exposures	Worst case exposures
Public				
Dermal				
Vegetation contact	8,100	4,100	10,000[a]	10,000
Dermal & inhalation drift	600	98	10,000	9,900
Dietary				
Water	8,700	1,400	10,000	10,000
Fish	2,700	430	10,000	10,000
Meat	10,000	2,300	10,000	10,000
Peas or beans	1,100	220	10,000	10,000
Berries	2,200	420	10,000	10,000
Cumulative				
Fisherman	1,600	300	10,000	10,000
Hunter	1,300	260	10,000	10,000
Workers				
Pilot	2,100	550	10,000	10,000
Mixer/loader	950	180	10,000	10,000
Observer	600	98	10,000	9,900
Card checker	450	110	10,000	10,000
E.E. team	75	28	7,700	2,900
Backpack	200	21	10,000	2,100
Accidents				
Spill onto worker		-99[b]		1.0
Broken hose		-49		2.1
Direct spray - adult		58		5,900
Direct spray - child		39		4,000
Peas or beans		130		10,000
Spill into water				
200 gallons into pond		2.1		210

[a]Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 7.38 and a reproductive NOEL of 751.
[b]When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

Table F4-6—Kerosene margins of safety

Scenario	Systemic: Typical exposures	Systemic: Worst case exposures	Reproductive: Typical exposures	Reproductive: Worst case exposures
Public				
Dermal				
Vegetation contact	10,000[a]	10,000	10,000	10,000
Dermal & inhalation drift	8,100	1,300	10,000	10,000
Dietary				
Water	10,000	10,000	10,000	10,000
Fish	10,000	5,600	10,000	10,000
Meat	10,000	10,000	10,000	10,000
Peas or beans	10,000	2,900	10,000	10,000
Berries	10,000	5,500	10,000	10,000
Cumulative				
Fisherman	10,000	4,000	10,000	10,000
Hunter	10,000	3,500	10,000	10,000
Workers				
Pilot	10,000	7,200	10,000	10,000
Mixer/loader	10,000	2,400	10,000	10,000
Observer	8,100	1,300	10,000	10,000
Card checker	6,100	1,500	10,000	10,000
E.E. team	1,000	370	10,000	9,978
Backpack	2,700	280	10,000	7,400
Accidents				
Spill onto worker		-26[b]		1.0
Broken hose		-3.7		7.2
Direct spray - adult		770		10,000
Direct spray - child		510		10,000
Peas or beans		1,700		10,000
Spill into water - 200 gallons into pond		27		730

[a]Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 28 and a reproductive NOEL of 751.
[b]When the exposure exceeded the NOEL, the MOS ratio was reversed and a minus sign added.

Table F4-7—*B.t.* margins of safety

Scenario	Typical	Worst Case
	Public	
Inhalation[a] (Drift)	5,000	1,900
Dietary[b]		
Water	10,000[c]	10,000
Peas or beans	10,000	10,000
Berries	10,000	10,000
Cumulative		
Hunter	10,000	10,000
	Workers	
Pilot[a]	10,000	6,100
Mixer/loader[a]	8,200	3,800
Observer[a]	5,000	1,900
	Accidents	
Peas or beans[b]		6,700
Spill into pond[b]		110

[a]Based on 1.4 mg/kg/day for human volunteer inhalation.
[b]Based on 500 mg/kg/day for rats feeding on 1 percent Biotrol in their diets.
[c]MOS's greater than 10,000 are listed as 10,000.

Table F4-8—Summary of spruce budworm insecticide margins of safety for the public for typical exposures

Chemical	MOS's for systemic effects	MOS's for reproductive effects
Acephate	MOS's less than 100 for drift (85), eating peas and beans (64), and for the hunter (86)	All greater than 100
Carbaryl	All greater than 100	All greater than 100
Malathion	MOS's less than 100 for drift (53), eating peas or beans (33), eating berries (65), for the fisherman (24), and for the hunter (45)	All greater than 100
Diesel oil	All greater than 100	All greater than 100
Kerosene	All greater than 100	All greater than 100
B. thuringiensis	All greater than 100	---

Table F4-9—Summary of spruce budworm insecticide margins of safety for the public routine-worst case exposures

Chemical	MOS's for systemic effects	MOS's for reproductive effects
Acephate	MOS's less than 100 for drift (28), eating fish (64), peas or beans (25), berries (48), and for the fisherman (44) and hunter (33)	All greater than 100
Carbaryl	MOS's less than 100 for drift (76), eating fish (92), and the fisherman (87)	MOS's less than 100 for drift (76), eating fish (92), and the fisherman (87)
Malathion	MOS's less than 100 for drift (16), drinking water (74), eating peas or beans (12), eating berries (22), and for the fisherman (7.1) and hunter (15)	All greater than 100
Diesel oil	MOS less than 100 for drift (98)	All greater than 100
Kerosene	All greater than 100	All greater than 100
B. thuringiensis	All greater than 100	---

Table F4-10—Margins of safety for humans from drinking contaminated water

Pesticide	Subarea	Human Dose (mg/kg/day)	NOEL (mg/kg/day)	Margin-of-Safety In Runoff
Acephate	A	0.000711	0.25	352
	B	0.000649	0.25	385
	C	0.000711	0.25	352
	Reservoir	0.000103	0.25	2,417
Malathion	A	0.000466	0.2	429
	B	0.000626	0.2	319
	C	0.000991	0.2	202
	Reservoir	0.000104	0.2	1,923
Carbaryl	A	0.00786	10.0	1,272
	B	0.00729	10.0	1,372
	C	0.00671	10.0	1,490
	Reservoir	0.00111	10.0	9,009

Table F4-11—Margins of safety for humans consuming crops grown with contaminated irrigation water

Insecticide	Dose (mg/kg/day)	NOEL (mg/kg/day)	MOS
Acephate	0.000277	0.25	903
Carbaryl	0.000178	10.0	56,180
Malathion	0.00126	0.2	159
Diesel	0.00150	7.38	4,920
Kerosene	0.00043	28	65,116

Table F4-12—Margins of safety for systemic effects for the public from accidents

Chemical	Adult sprayed	Child sprayed	Eat from sprayed garden	Drink water from pond spill
Acephate	17	11	15	-4.2
Carbaryl	45	30	300	4.8
Malathion	9.4	6.3	6.8	-9.1
Diesel oil	58	39	130	2.1
Kerosene	770	510	1,700	27
B. thuringiensis	--	--	6,700	110

Table F4-13—Summary of spruce budworm insecticide margins of safety for workers in routine-typical exposures

Chemical	MOS's for systemic effects	MOS's for reproductive effects
Acephate	MOS's less than 100 for observer (85), card checker (70), and backpack sprayer (29)	All greater than 100
Carbaryl	MOS less than 100 for backpack sprayer (79)	MOS less than 100 for backpack sprayer (79)
Malathion	MOS's less than 100 for mixer/ loader (83), observer (53), card checker (41), E.E. team (77), and backpack sprayer (18)	All greater than 100
Diesel oil	MOS less than 100 for E.E. team (75)	All greater than 100
Kerosene	All greater than 100	All greater than 100
B. thuringiensis	All greater than 100	All greater than 100

Table F4-14—Summary of spruce budworm insecticide margins of safety for workers in routine-worst case exposures

Chemical	MOS's for systemic effects	MOS's for reproductive effects
Acephate	MOS's less than 100 for mixer/loader (51), observer (28), card checker (34), and backpack sprayer (6.1)	MOS less than 100 for backpack sprayer (73)
Carbaryl	MOS less than 100 for observer (76), card checker (89), and backpack sprayers (16)	MOS less than 100 for observer (76), card checker (89), and backpack sprayer (16)
Malathion	MOS's less than 100 for pilot (86), mixer/loader (29), observer (16), card checker (18), E.E. team (23), and backpack sprayer (3.4)	All greater than 100
Diesel oil	MOS's less than 100 for observer (98), E.E. team (28), and backpack sprayer (21)	All greater than 100
Kerosene	All greater than 100	All greater than 100
B. thuringiensis	All greater than 100	All greater than 100

Table F4-15—Worker risk from accidents

Chemical	Spill on worker		Broken hose		Accidental spray	
	Systemic	Repro.	Systemic	Repro.	Systemic	Repro.
Acephate	-340	-29	-170	-14	17	200
Carbaryl	-130	-130	-63	-63	45	45
Malathion	-1,400	-13	-310	-2.8	9.4	1,000
Diesel oil	-99	1.0	-49	2.1	58.0	5,900
Kerosene	-26	1.0	-3.7	7.2	770	10,000
B. thuringiensis	--	--	--	--	--	--

Table F4-16—Lifetime cancer risk[a]

Scenario	Acephate	Carbaryl	Malathion	Diesel Oil	Kerosene
Public					
Dermal & inhalation drift	1.3E-08	NA[b]	7.9E-09	3.6E-11	1.0E-11
Dietary					
Water	2.2E-09	6.4E-10	1.7E-09	2.5E-12	7.1E-13
Fish	5.5E-09	2.2E-08	1.5E-08	8.1E-12	2.3E-12
Meat	1.0E-09	6.0E-10	7.2E-10	1.4E-12	4.1E-13
Peas or beans	1.6E-08	4.8E-09	1.2E-08	1.8E-11	5.1E-12
Berries	8.3E-09	2.4E-09	6.2E-09	9.1E-12	2.6E-12
Cumulative					
Fisherman	8.5E-09	2.3E-08	1.7E-08	1.2E-11	3.6E-12
Hunter	1.2E-08	3.7E-09	9.0E-09	1.5E-11	4.3E-12
Workers					
Pilot	1.2E-07	NA	7.6E-08	3.2E-10	9.0E-11
Mixer/loader	2.9E-07	NA	1.8E-07	7.9E-10	2.2E-10
Observer	4.8E-07	NA	2.9E-07	1.3E-09	3.7E-10
Card checker	5.3E-07	NA	3.4E-07	1.5E-09	4.3E-10
E. E. team	2.7E-11	NA	2.0E-07	8.1E-09	2.3E-09
Backpack sprayer	3.2E-07	NA	2.0E-07	9.8E-10	2.8E-10
Accidents					
Spill onto worker	3.1E-05	NA	4.8E-05	1.4E-07	1.4E-07
Broken hose	1.6E-05	NA	1.0E-05	7.0E-08	2.0E-08
Accidental spray					
--adult	5.4E-09	NA	3.6E-09	2.4E-11	7.0E-12
--child	8.1E-09	NA	5.4E-09	3.6E-11	1.0E-11
Peas or beans	6.2E-09	1.8E-09	5.0E-09	1.1E-11	3.2E-12
Spill into pond					
--200 gallons	3.8E-07	1.1E-07	3.1E-07	6.9E-10	2.0E-10

[a]Risks are upper 95 percent confidence limits.
[b]Not applicable—carbaryl's carcinogenic risk is calculated for oral exposures only, by calculating risk of digestive system formation of N-nitrosocarbaryl. (See the hazard analysis (section F2).

Table F4-17—Lifetime risk of death or cancer[a] resulting from everyday activities

Activity	Time to accumulate a 1-in-1 million risk of death	Average annual risk[c] per capita
Motor vehicle accident	1.5 days	2×10^{-4}
Falls	6 days	6×10^{-5}
Drowning	10 days	4×10^{-5}
Fires	13 days	3×10^{-5}
Firearms	36 days	1×10^{-5}
Electrocution	2 months	5×10^{-6}
Tornados	20 months	6×10^{-7}
Floods	20 months	6×10^{-7}
Lightning	2 years	5×10^{-7}
Animal bite or sting	4 years	2×10^{-7}
Occupational risks		
General		
Manufacturing	4.5 days	8×10^{-5}
Trade	7 days	5×10^{-5}
Service and government	3.5 days	1×10^{-4}
Transport and public utilities	1 day	4×10^{-4}
Agriculture	15 hours	6×10^{-4}
Construction	14 hours	6×10^{-4}
Mining and quarrying	9 hours	1×10^{-3}
Specific		
Coal mining (accidents)	14 hours	6×10^{-4}
Police duty	1.5 days	2×10^{-4}
Railroad employment	1.5 days	2×10^{-4}
Firefighting	11 days	8×10^{-4}
Everyday risks		
Eating and drinking	40 diet sodas (saccharin)	--
	6 pounds of peanut butter (aflatoxin)	--
	180 pints of milk (aflatoxin)	--
	200 gallons of drinking water from Miami or New Orleans	
	90 pounds of broiled steak (cancer risk only)	--
Smoking	2 cigarettes	--

[a]Cancer risks shown in this table were calculated based on a variety of assumptions that tend to overestimate risk as explained in section F5.
[b]For persons living in the United States.
[c]For lifetime risk, multiply average annual risk by 70.

Table F4-18—Petroleum distillates: diesel oil + kerosene margins of safety

Scenario	Systemic		Reproductive	
	Typical exposures	Worst case exposures	Typical exposures	Worst case exposures
Public				
Dermal				
Vegetation contact	6,300	3,200	10,000	10,000
Dermal & inhalation drift	470	76	10,000	7,707
Dietary				
Water	6,800	1,100	10,000	10,000
Fish	2,100	330	10,000	10,000
Meat	10,000	1,800	10,000	10,000
Peas or beans	870	170	10,000	10,000
Berries	1,700	320	10,000	10,000
Cumulative				
Fisherman	1,300	240	10,000	10,000
Hunter	1,000	200	10,000	10,000
Workers				
Pilot	1,700	420	10,000	10,000
Mixer/loader	740	140	10,000	10,000
Observer	470	76	10,000	7700
Card checker	350	88	10,000	8,900
E.E. team	59	22	6,000	2,200
Backpack sprayer	160	16	10,000	1,700
Accidents				
Spill onto worker		-99[a]		1.0
Broken hose		-64		1.6
Accidental spray--adult	45			4,600
Accidental spray--child	30			3,100
Peas or beans	100			10,000
Spill into water				
200 gallons into pond	1.6			160

[a]Margins of safety greater than 10,000 are listed as 10,000. Margins of safety were based on a systemic NOEL of 7.38 and a reproductive NOEL of 751.

Table F4-19—Acephate wildlife risk

Representative species	Realistic dose (mg/kg)	Extreme dose (mg/kg)	1/5 LD_{50}	LD^{50}	Reference species
Flicker	2.1	11	21.2	106	Dark-eyed junco
Dove	1.7	8.6	21.2	106	Dark-eyed junco
Jay	2.2	11	21.2	106	Dark-eyed junco
Kingfisher	0.96	4.7	21.2	106	Dark-eyed junco
Screech owl	3.0	15	21.2	106	Dark-eyed junco
Mouse	6.3	31	30	150	Mouse
Rabbit	0.80	5.5	106	530	Rabbit
Deer	0.89	1.1	173	866	Rat
Fox	0.50	2.5	173	866	Rat
Toad	2.9	14	1,287	6,433	Green frog
Snake	3.6	18	1,287	6,433	Green frog
Cow	0.68	1.3	173	866	Rat
Chicken	0.28	1.5	114	568	Chicken
Dog	0.11	0.52	173	866	Rat

Table F4-20—Carbaryl wildlife risk

Representative species	Realistic dose (mg/kg)	Extreme dose (mg/kg)	1/5 LD_{50}	LD_{50}	Reference species
Flicker	6.1	31	156	780	Grouse
Dove	5.2	26	156	780	Grouse
Jay	6.4	32	156	780	Grouse
Kingfisher	4.3	19	156	780	Grouse
Screech owl	8.3	41	156	780	Grouse
Mouse	15.4	77	55	275	Mouse
Rabbit	2.8	17	142	710	Rabbit
Deer	0.52	3.8	40	200	Mule deer
Fox	1.9	9.6	30	150	Cat
Toad	40	200	156	780	Grouse
Snake	52	260	156	780	Grouse
Cow	0.32	3.6	40	200	Mule deer
Chicken	1.4	6.9	156	780	Grouse
Dog	0.79	3.9	30	150	Cat

Table F4-21—Malathion wildlife risk

Representative species	Realistic dose (mg/kg)	Extreme dose (mg/kg)	1/5 LD_{50}	LD_{50}	Reference species
Flicker	3.8	21	30	150	Chicken
Dove	3.0	17	30	150	Chicken
Jay	4.0	22	30	150	Chicken
Kingfisher	1.9	9.8	30	150	Chicken
Screech owl	5.3	29	30	150	Chicken
Mouse	11	62	155	775	Mouse
Rabbit	1.4	11	10.6	53	Rabbit
Deer	0.15	2.1	16	80	Dairy calves
Fox	0.88	4.9	74	370	Rat
Toad	4.3	24	30	150	Chicken
Snake	5.3	29	30	150	Chicken
Cow	0.12	2.6	16	80	Dairy calves
Chicken	0.48	2.9	30	150	Chicken
Dog	0.18	0.96	74	370	Rat

Table F4-22—Diesel oil wildlife risk

Representative species	Realistic dose (mg/kg)	Extreme dose (mg/kg)	1/5 LD_{50}	LD_{50}	Reference species
Flicker	4.0	40	3,280	16,400	Mallard
Dove	3.3	33	3,280	16,400	Mallard
Jay	4.2	42	3,280	16,400	Mallard
Kingfisher	1.9	19	3,280	16,400	Mallard
Screech owl	5.5	55	3,280	16,400	Mallard
Mouse	11	110	1,476	7,380	Rat
Rabbit	1.6	21	1,476	7,380	Rat
Deer	0.22	4.3	1,476	7,380	Rat
Fox	1.0	10	1,476	7,380	Rat
Toad	12	120	3,280	16,400	Mallard
Snake	15	150	3,280	16,400	Mallard
Cow	0.15	4.9	1,476	7,380	Rat
Chicken	0.63	6.7	3,280	16,400	Mallard
Dog	0.30	2.9	1,476	7,380	Rat

Table F4-23—Kerosene wildlife risk

Representative species	Realistic dose (mg/kg)	Extreme dose (mg/kg)	1/5 LD_{50}	LD_{50}	Reference species
Flicker	1.1	12	3,280	16,400	Mallard
Dove	0.93	9.5	3,280	16,400	Mallard
Jay	1.2	12	3,280	16,400	Mallard
Kingfisher	0.54	5.5	3,280	16,400	Mallard
Screech owl	1.6	16	3,280	16,400	Mallard
Mouse	3.2	32	5,600	28,000	Rat
Rabbit	0.45	6.1	5,600	28,000	Rat
Deer	0.062	1.2	5,600	28,000	Rat
Fox	0.29	3.0	5,600	28,000	Rat
Toad	3.3	34	3,280	16,400	Mallard
Snake	4.2	43	3,280	16,400	Mallard
Cow	0.043	1.4	5,600	28,000	Rat
Chicken	0.18	1.9	3,280	16,400	Mallard
Dog	0.084	0.84	5,600	28,000	Rat

Table F4-24—Acute risk[a] from acephate to aquatic species in varying water depths from routine operations

Representative species	LC_{50} or EC_{50} (ppb)	Q-values (EEC/LC_{50}) Depth = 2 inches	Depth = 6 inches	Depth = 1 foot	Depth = 2 feet
	Typical EEC =	210 ppb	70 ppb	35 ppb	18 ppb
Rainbow trout	730	0.29*	0.096	0.048	0.024
Brook trout	100	2.1**	0.70**	0.35*	0.18*
Cutthroat trout	100	2.1**	0.70**	0.35*	0.18*
Largemouth bass	1,725	0.12*	0.040	0.020	0.010
Smallmouth bass	1,725	0.12*	0.040	0.020	0.010
Bluegill	1,000	0.21*	0.070	0.035	0.018
Yellow perch	100	2.1**	0.70**	0.35*	0.18*
Water flea	--	--	--	--	--
Stonefly	9.5	22**	7.4**	3.7**	1.8**
Scud	50	4.2**	1.4**	0.70**	0.35*
	Worst case EEC =	650 ppb	220 ppb	110 ppb	54 ppb
Rainbow trout	730	0.89**	0.30*	0.15*	0.074
Brook trout	100	6.5**	2.2**	1.1**	0.54**
Cutthroat trout	100	6.5**	2.2**	1.1**	0.54**
Largemouth bass	1,725	0.38*	0.13*	0.063	0.031
Smallmouth bass	1,725	0.38*	0.13*	0.063	0.031
Bluegill	1,000	0.65**	0.22*	0.11*	0.054
Yellow perch	100	6.5**	2.2**	1.1**	0.54**
Water flea	--	--	--	--	--
Stonefly	9.5	68**	23**	11**	5.7**
Scud	50	13**	4.3**	2.2**	1.1**

[a]* = Moderate risk; ** = Significant risk.

Table F4-25—Acute risk[a] from carbaryl to aquatic species in varying water depths from routine operations

Representative species	LC_{50} or EC_{50} (ppb)	Q-values (EEC/LC_{50}) Depth = 2 inches	Depth = 6 inches	Depth = 1 foot	Depth = 2 feet
	Typical EEC =	420 ppb	140 ppb	70 ppb	35 ppb
Rainbow trout	1,950	0.22*	0.072	0.036	0.018
Brook trout	1,100	0.38*	0.13*	0.064	0.032
Cutthroat trout	1,500	0.28*	0.093	0.047	0.023
Largemouth bass	6,400	0.066	0.022	0.011	0.0054
Smallmouth bass	6,400	0.066	0.022	0.011	0.0054
Bluegill	39,000	0.011	0.0036	0.0018	0.00090
Yellow perch	5,100	0.082	0.028	0.014	0.0068
Water flea	6.4	66**	22**	11**	5.4**
Stonefly	1.7	250**	82**	42**	20**
Scud	22	19**	6.4**	3.2**	1.6**
	Worst case EEC =	1,300 ppb	430 ppb	220 ppb	110 ppb
Rainbow trout	1,950	0.67**	0.22*	0.11*	0.055
Brook trout	1,100	1.2**	0.40*	0.20*	0.098
Cutthroat trout	1,500	0.87**	0.29*	0.14*	0.072
Largemouth bass	6,400	0.20*	0.068	0.034	0.017
Smallmouth bass	6,400	0.20*	0.068	0.034	0.017
Bluegill	39,000	0.033	0.011	0.0056	0.0028
Yellow perch	5,100	0.26*	0.085	0.042	0.021
Water flea	6.4	200**	68**	34**	17**
Stonefly	1.7	760**	260**	130**	64**
Scud	22	59**	20**	9.9**	4.9**

[a]* = Moderate risk; ** = Significant risk

Table F4-26—Acute risk[a] from malathion to aquatic species in varying water depths from routine operations

Representative species	LC_{50} or EC_{50} (ppb)	Q-values (EEC/LC_{50}) Depth = 2 inches	Depth = 6 inches	Depth = 1 foot	Depth = 2 feet
	Typical EEC =	380 ppb	130 ppb	63 ppb	31 ppb
Rainbow trout	200	1.9**	0.63**	0.31*	0.16*
Brook trout	200	1.9**	0.63**	0.31*	0.16*
Cutthroat trout	280	1.4**	0.45*	0.22*	0.11*
Largemouth bass	285	1.3**	0.44*	0.22*	0.11*
Smallmouth bass	285	1.3**	0.44*	0.22*	0.11*
Bluegill	103	3.7**	1.2**	0.61**	0.36*
Yellow perch	263	1.4**	0.48*	0.24*	0.12*
Water flea	1	380**	130**	63**	31**
Stonefly	0.69	550**	180**	91**	46**
Scud	0.76	500**	170**	83**	41**
	Worst case EEC =	1,300 ppb	430 ppb	220 ppb	110 ppb
Rainbow trout	200	6.5**	2.15**	1.1**	0.54**
Brook trout	200	6.5**	2.15**	1.1**	0.54**
Cutthroat trout	280	4.6**	1.6**	0.78**	0.39*
Largemouth bass	285	4.6**	1.5**	0.76**	0.38*
Smallmouth bass	285	4.6**	1.5**	0.76**	0.38*
Bluegill	103	13**	4.2**	2.1**	1.40**
Yellow perch	263	4.9**	1.6**	0.82**	0.41*
Water flea	1	1,300**	43**	220**	110**
Stonefly	0.69	1,900**	630**	310**	160**
Scud	0.76	1,700**	570**	280**	140**

[a]* = Moderate risk; ** = Significant risk

Table F4-27—Acute risk[a] from petroleum from to aquatic species in varying water depths from routine operations

Representative species	LC_{50} or EC_{50} (ppb)	Q-values (EEC/LC_{50}) Depth = 2 inches	Depth = 6 inches	Depth = 1 foot	Depth = 2 feet
	Typical EEC =	460 ppb	150 ppb	76 ppb	38 ppb
Rainbow trout	190	2.4**	0.80**	0.40*	0.20*
Brook trout	190	2.4**	0.80**	0.40*	0.20*
Cutthroat trout	190	2.4**	0.80**	0.40*	0.20*
Largemouth bass	190	2.4**	0.80**	0.40*	0.20*
Smallmouth bass	190	2.4**	0.80**	0.40*	0.20*
Bluegill	190	2.4**	0.80**	0.40*	0.20*
Yellow perch	190	2.4**	0.80**	0.40*	0.20*
Water flea	210	2.2**	0.72**	0.36*	0.18*
Stonefly	--	--	--	--	--
Scud	--	--	--	--	--
	Worst case EEC =	2,800 ppb	950 ppb	480 ppb	240 ppb
Rainbow trout	190	15**	5.0**	2.5**	1.2**
Brook trout	190	15**	5.0**	2.5**	1.2**
Cutthroat trout	190	15**	5.0**	2.5**	1.2**
Largemouth bass	190	15**	5.0**	2.5**	1.2**
Smallmouth bass	190	15**	5.0**	2.5**	1.2**
Bluegill	190	15**	5.0**	2.5**	1.2**
Yellow perch	190	15**	5.0**	2.5**	1.2**
Water flea	210	14**	4.5**	2.3**	1.1**
Stonefly	--	--	--	--	--
Scud	--	--	--	--	--

[a]* = Moderate risk; ** = Significant risk

Table F4-28—Acute toxicity risk analysis for acephate for accidents

Representative species	LC_{50} or EC_{50} (ppb)	Q-value (EEC/LC_{50})	Risk level[a]
200 gallon spill into pond, EEC = 36,800 ppb			
Rainbow trout	730	5.04E+01	Significant
Brook trout	100	3.68E+02	Significant
Cutthroat trout	100	3.68E+02	Significant
Largemouth bass	1,725	2.13E+01	Significant
Smallmouth bass	1,725	2.13E+01	Significant
Bluegill	1,000	3.68E+01	Significant
Yellow perch	100	3.68E+02	Significant
Water flea	--	--	No Data
Stonefly	9.5	3.88E+03	Significant
Scud	50	7.37E+02	Significant
Direct spraying of water body at Maximum Rate, EEC = 91.9 ppb			
Rainbow trout	730	0.1260	Moderate
Brook trout	100	0.9200	Significant
Cutthroat trout	100	0.9200	Significant
Largemouth bass	1,725	0.0533	Low
Smallmouth bass	1,725	0.0533	Low
Bluegill	1,000	0.0920	Low
Yellow perch	100	0.9200	Significant
Water flea	--	--	Low
Stonefly	9.5	9.6842	Significant
Scud	50	1.8400	Significant

[a]No risk = Q-value < 0.1; moderate = Q-value > 0.1 and < 0.5; significant = Q-value > 0.5.

Table F4-29—Acute toxicity risk analysis for carbaryl for accidents

Representative species	LC_{50} or EC_{50} (ppb)	Q-value (EEC/LC_{50})	Risk level
200 gallon spill into pond, EEC = 7,350 ppb			
Rainbow trout	1,950	3.78E+01	Significant
Brook trout	1,100	6.70E+01	Significant
Cutthroat trout	1,500	4.91E+01	Significant
Largemouth bass	6,400	1.15E+01	Significant
Smallmouth bass	6,400	1.15E+01	Significant
Bluegill	39,000	1.8885	Significant
Yellow perch	5,100	1.44E+01	Significant
Water flea	6.4	1.15E+04	Significant
Stonefly	1.7	4.33E+04	Significant
Scud	22	3.35E+03	Significant
Direct spraying of water body at Maximum Rate, EEC = 184 ppb			
Rainbow trout	1,950	0.0944	Low
Brook trout	1,100	0.1673	Moderate
Cutthroat trout	1,500	0.1227	Moderate
Largemouth bass	6,400	0.0288	Low
Smallmouth bass	6,400	0.0288	Low
Bluegill	39,000	0.0047	Low
Yellow perch	5,100	0.361	Low
Water flea	6.4	2.88E+01	Significant
Stonefly	1.7	1.08E+02	Significant
Scud	22	8.3636	Significant

Table F4-30—Acute toxicity risk analysis for malathion for accidents

Representative species	LC_{50} or EC_{50} (ppb)	Q-value (EEC/LC_{50})	Risk level
200 gallon spill into pond, EEC = 73,500 ppb			
Rainbow trout	200	3.68E+02	Significant
Brook trout	200	3.68E+02	Significant
Cutthroat trout	280	2.63E+02	Significant
Largemouth bass	285	2.58E+02	Significant
Smallmouth bass	285	2.58E+02	Significant
Bluegill	103	7.15E+02	Significant
Yellow perch	263	2.80E+02	Significant
Water flea	1	7.37E+04	Significant
Stonefly	.69	1.07E+05	Significant
Scud	.76	9.69E+04	Significant
Direct spraying of water body at Maximum Rate, EEC = 184 ppb			
Rainbow trout	200	0.9200	Significant
Brook trout	200	0.9200	Significant
Cutthroat trout	280	0.6571	Significnat
Largemouth bass	285	0.6456	Significant
Smallmouth bass	285	0.6456	Significant
Bluegill	103	1.7864	Significant
Yellow perch	263	0.6996	Significant
Water flea	1	1.84E+02	Significant
Stonefly	.69	2.67E+02	Significant
Scud	.76	2.42E+02	Significant

Table F4-31—Acute toxicity from petroleum distillates to aquatic species from accidents

Representative species	LC_{50} or EC_{50} (ppb)	Q-value (EEC/LC_{50})	Risk level
200 gallon spill into pond, EEC = 161 ppb			
Rainbow trout	0.19	850	Significant
Brook trout	0.19	850	Significant
Cutthroat trout	0.19	850	Significant
Largemouth bass	0.19	850	Significant
Smallmouth bass	0.19	850	Significant
Bluegill	0.19	850	Significant
Yellow perch	0.19	850	Significant
Water flea	0.21	770	Significant
Stonefly	--	--	No data
Scud	--	--	No data
Direct spraying of water body at Maximum Rate, EEC = 0.403 ppb			
Rainbow trout	0.19	2.1	Significant
Brook trout	0.19	2.1	Significant
Cutthroat trout	0.19	2.1	Significant
Largemouth bass	0.19	2.1	Significant
Smallmouth bass	0.19	2.1	Significant
Bluegill	0.19	2.1	Significant
Yellow perch	0.19	2.1	Significant
Water flea	0.21	1.9	Significant
Stonefly	--	--	No data
Scud	--	--	No data

Attachment F-A

Environmental Fate

Malathion

Physical and Chemical Properties

Malathion is an organophosphate insecticide that exists as a colorless to light amber liquid at standard conditions (25 °C, 1 atmosphere pressure). The preferred chemical name of malathion is O,O-dimethyl phosphorodithioate of diethyl mercaptosuccinate. (Figure FA-1 shows its chemical structure.) Its physical and chemical properties are listed in table FA-1 (Dobroski and Lambert, 1984).

Fate in Soil

Verschueren (1983) cites a soil half-life for malathion of 0.5 days. In alkaline soils with low organic content and low microbial populations, basic hydrolysis may be the primary reaction in the degradation of malathion. Reaction half-lives on the order of 7.5 to 11 days were found in low organic content soils (Gibson and Burns, 1977). Degradation of malathion in higher organic content soils occurs through biologically mediated catalysis by exoenzymes and nonbiological hydrolysis. The breakdown of malathion by exoenzymes occurs from enzyme activity in soil humus and the metabolic activity of microbes. Degradation by enzymes in soil humus is the most rapid process; thus, malathion is rapidly consumed in moist soils with significant organic content (Gibson and Burns, 1977). Degradation by direct metabolic activity of soil microbes is important only when the enzyme is not present in soil organic matter (Getzin and Rosefield, 1971, as cited in Dobroski and Lambert, 1984). Microbes that metabolize malathion include species of the bacteria *Anthrobacter* and *Tricoderma* and the fungi *Rhizobium* (Matsumura and Baush, 1966; Walker and Stojanovic, 1973).

Malaoxon is a common degradation product of malathion in the soil. It is of concern because its toxicity level is similar to that of malathion. Degradation of malaoxon is primarily by basic hydrolysis (Pascal and Neville, 1976), and half-lives of 3.9 to 5 days were found for soils of pH 7.2 to pH 8.2.

Transport of malathion from the soil environment to the atmosphere should be negligible because malathion is a chemical of low volatility (1.25×10^{-4} mm Hg at 20 °C). Leaching should be insignificant because malathion is relatively tightly held to soil particles. An adsorption coefficient (Kd) of 892 mL/g has been reported (Curley and Donohue, 1986).

Fate in Air

Photolysis of malathion and related compounds is too slow to be considered important to the degradation of malathion (Toia et al., 1980). However, the low volatility of malathion discounts both the likelihood of its presence in air as a vapor and its persistence in the atmosphere. Significant transport of malathion should occur only by drift during application.

Fate in the Aquatic Environment

Degradation of malathion in aquatic environments occurs through basic hydrolysis and microbial activity. Wolfe et al. (1977) found a 36-hour half-life for malathion from basic hydrolysis (pH 8, 27 °C). Degradation products and reaction intermediates include DPTA, diethyl fumarate, monocarboxylic and dicarboxylic acids of malathion, and thiosuccinic acid. Malathion monoacids are also products of hydrolysis and have a half-life of 26 days for inorganic degradation. Biological degradation has been reported to eliminate malathion from river water in 28 days with 75 percent removed in 1 week (Eichelberger and Lichtenberg, 1971). Malathion monoacids have been detected as the primary degradation products from biological reactions. The monoacids persist after malathion has been eliminated (Bourquin, 1977, as cited in Ghassemi et al., 1981). The degradation products of biological reactions are eliminated only by further degradation reactions (Wolfe et al., 1977). The degradation of malathion may be accelerated by photolysis under ultraviolet radiation. Natural river water with a large amount of organic matter resulted in a half-life for malathion of 15 to 16 hours under sunlight photolysis (Wolfe et al., 1977).

Table FA-1—Properties of malathion

Purity	98.5 - 99.5 percent (analytical grade) 91.95 percent (technical grade)
Boiling point	156 °C (at 0.7 torr)[a]
Melting point	2.85 °C
Refractive index	1.4985 (25 °C)
Specific gravity	1.232 (25 °C)
Vapor pressure	1.25 x 10^{-4} mm Hg (20-25 °C)
Octanol-water coefficient	776
Solubility in water	145 ppm (20-25 °C)
Organic carbon partition coefficient	1800

[a]1 torr = 1/760 of an atmosphere.

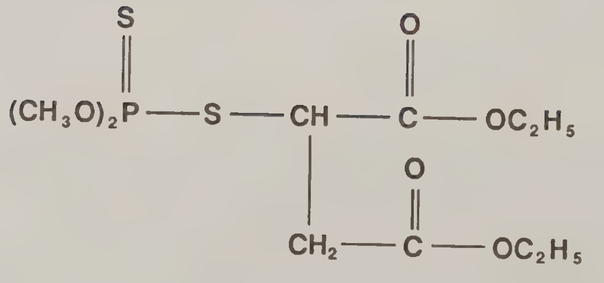


Figure FA-1—Structure of malathion

Malathion may be removed from aquatic environments by adsorption to suspended particulates (half-life of 3 days for estuarine sediments (Walker, 1976)). Because of its physical properties, malathion is not removed from aquatic environments by volatilization or precipitation as a solid.

Fate in Plants

Degradation of malathion on plant surfaces has been reported with half-lives of 15 to 21 hours (Saini and Dobough, 1970) to 5 days (Nigg et al., 1981). Half-lives of ULV applications of malathion at 29.4 °C and 40.5 °C were 21 and 15 hours, respectively. The half-life of malathion residues on citrus foliage was found to be approximately 5.2 days. Residues of emulsifiable concentrate had half-lives of approximately half the ULV residues. Degradation or disappearance of malathion from plant surfaces showed varying rates. The interval for complete dissipation of malathion (by bioassay) was 5 days on bean plants and 6 days on clover plants. For peaches, the safe interval between malathion treatment and consumption was 1 to 2 days (Dobroski and Lambert, 1984). Trace levels of malathion on plants after 1 week have also been found in other studies (Kashyap and Hameed, 1982, as cited in Dobroski and Lambert, 1984).

Malathion has been found to damage a variety of fruit trees and vegetable plants (Thomson, 1979). Affected plants include string beans, apples, Bosc pears, cherries, European grapes, and cucurbits. Some ornamental plants were also affected by malathion. Phytotoxicity of malathion to forested areas was not observed after application at 0.72 lb a.i./acre (Giles, 1970).

Bioaccumulation

The bioaccumulation potential for malathion is low. Its low octanol-water partition coefficient (780) and high solubility (145 mg/L at 28 °C) reflect its low potential for accumulation in lipids (Dobroski and Lambert, 1984). In acidic waters, where malathion is more stable, carp did not bioaccumulate significantly above the level in the water (Bender, 1969). Retention after exposure revealed a half-life of 12 hours in tissue, reflecting relatively rapid elimination of malathion from tissues after cessation of exposure (Kenaga and Goring, 1980, as cited in Dobroski and Lambert, 1984).

Carbaryl

Chemical and Physical Properties

Carbaryl is a carbamate pesticide that exists as a white, crystalline powder in pure form and is tan, lavender, or pink in its technical formulation. The chemical name of carbaryl is 1-napthyl-N-methyl carbamate. (Figure FA-2 shows the structure of carbaryl.) Its physical and chemical properties have been summarized in Dobroski (1985). (See table FA-2.)

Fate in Soil

EPA (1988) reports that soil half-lives for carbaryl range from 7 to 28 days in aerobic and anaerobic soils, respectively. Degradation of carbaryl in the soil zone results primarily from the metabolic activity of microorganisms (Heywood, 1975). A half-life in soil of 8 days has been reported by Johnson and Stansbury (1965). Only 6 percent of applied carbaryl could be recovered from treated soil 28 days after application. In addition, less than 3 percent remained as water-soluble metabolites. Degradation of carbaryl by soil microorganisms produces several toxic reaction intermediates, including 1-napthol and hydroxy-methylcarbamates. Heywood (1975) also found that 68 percent of hydroxylated metabolites were broken down in soil after 9 weeks. Soils placed in storage were found to degrade a variety of carbamate insecticides at a lower rate. Carbaryl has been found to be degraded by the soil fungus *Aspergillus terreus* (Liu and Bollag, 1971). Carbaryl degraded with a half-life of 6 days in *A. terreus* cultures, and 1-napthol also was metabolized into unidentified degradation products. Soil mite populations are unaffected by carbaryl (Moulding, 1972). Catalysis of carbaryl degradation by soil minerals is not well understood, but it is clear that the degradation of carbaryl in soils can be attributed more to biological activity than to soil mineral composition (Heywood, 1975).

Field applications of carbaryl were conducted to determine the potential for ground-water contamination (LaFleur, 1976). Soil and ground-water samples were taken at monthly intervals. No carbaryl was found in

Table FA-2—Properties of carbaryl

Purity	80 percent (Sevin sprayable formulation)
Melting point	142 °C
Specific gravity	1.232 (20 °C)
Vapor pressure	4.1×10^{-5} mm Hg (25 °C)
Solubility in water	40 mg/L (25 °C)
Octanol-water coefficient	651
Organic carbon partition coefficient	230

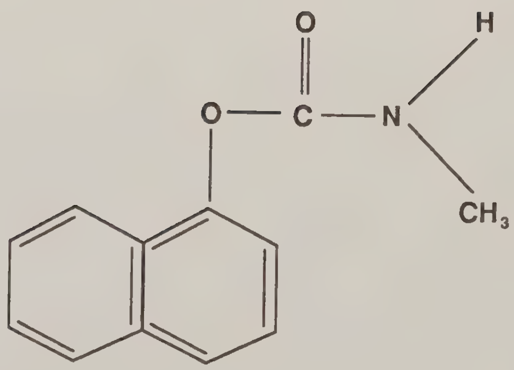


Figure FA-2—Structure of carbaryl

the upper 20 cm of soil after the fourth month (initial application of 50 micromoles per kilogram (µmol/kg) soil. Carbaryl desorption values (k_b) of 1.6 to 0.31 were calculated from field data, and sorption was correlated to organic content of the soil. Concentrations of carbaryl in ground water peaked at 0.3 µmol/L (60 ppb) 2 months after application and dropped to 0.1 µmol/L after 4 months. These values represent a maximum for potential migration to ground water because of field conditions (water table depth of 1.1 m and precipitation of 11.4 cm/month). Little transport of carbaryl by soil water is expected because of its low solubility (40 ppm) and rapid degradation in soils.

Because of its low volatility (0.005 mm Hg) (Dolinger and Fitch, 1979), transfer of carbaryl from soils to the atmosphere is too slow to be significant in removing carbaryl from the soil.

Fate in Air

Carbaryl is not expected to be present in air as a vapor because of its low volatility (0.005 mm Hg). Studies of ambient air concentrations of pesticides have not detected carbaryl (Kutz et al., 1976, as cited in Dolinger and Fitch, 1979).

Fate in the Aquatic Environment

Carbaryl degrades rapidly in water in 1 to 5 days. Carbaryl applied over open water, such as small brooks or ponds, at an initial deposit of 1 ppm or less in a water depth of about 4 inches may be expected to degrade completely or disappear in 1 or 2 days (Romine and Bussian, 1971; California Department of Fish and Game, 1963; Lichenstein et al., 1966). Results were similar for water treated with Sevin® 4-Oil during a gypsy moth suppression project (Willcox, 1972).

The biodegradation rate constant for carbaryl in water is 2.4 x 10^{-10} mL of substrate/bacterial cell/day (Lyman et al., 1982, as cited in Dobroski, 1985). The greater the number of bacterial cells in the water, the faster carbaryl will biodegrade. The major metabolite of microbial degradation of carbaryl is 1-naphthol. In a detailed 3-year study of carbaryl in aquatic environments (Felley, 1970), no residues of carbaryl or its major metabolite, 1-naphthol, ever exceeded 0.1 ppm in areas where the pesticide was applied at 1 lb per acre. The ultimate degradation product is carbon dioxide, but investigators in one study suspected that 1-naphthol may be converted to an unidentified, but fairly stable, metabolite that is approximately two-thirds as toxic as 1-naphthol to organisms such as bay mussels (Lamberton and Claeys, 1970).

Carbaryl may be rapidly degraded by hydrolysis at neutral to alkaline pH values (Wolfe et al., 1978; Aly and El-Dib, 1971). These kinetic studies determined half-lives of 1.3 to 1.5 days at a pH of 8. Wolfe et al. (1978) found a half-life for photolysis of carbaryl of 6.6 days. Carbaryl was found to be less persistent in natural water at higher pH values (Szeto et al., 1979). This study found biological degradation was significant in the removal of carbaryl; however, these waters existed under conditions that retarded hydrolysis (pH less than 7.5, 9 °C). Only 5 percent of applied carbaryl was recovered from river water after 1 week (Eichelberger and Lichtenberg, 1971).

Under conditions expected in the areas sprayed to control spruce budworm, hydrolysis and photolysis should be the primary pathways for the degradation of carbaryl, and rapid elimination is indicated in studies of laboratory and natural samples.

Fate in Plants

The low vapor pressure of carbaryl makes it unlikely that it will volatilize from plant surfaces. The susceptibility of carbaryl to photolysis and its low solubility minimize the possibility of washoff from plants.

Various field studies have been conducted to determine the persistence of carbaryl residues on plants. Residues of Sevin® 4-Oil, applied at 0.75 lb a.i./acre in northeastern forests, were found on foliage 60 days after treatment (Ghassemi et al., 1981). A field study of carbaryl residues on foliage, when Sevin® 4-Oil was applied at 1 lb a.i./acre, showed the half-life on grass as 8 days, on geraniums as 3 days, on aspens as 8 days, and on Douglas-fir as 4.5 days (Pieper, 1979, as cited in Ghassemi et al., 1981). This study also reported grass to have the highest percent residue recovered (89.5 percent). In a field study in India, the half-life calculated for cabbage was 3 days and 3.2 days for eggplants (Mann and Chopra, 1969). The calculated half-life of carbaryl, when applied to apple leaves at 0.5 and 1 lb a.i./100 gal, was 13.33 days with

a 90-percent reduction in the average surface residue 31 days after treatment (Sell and Maitlen, 1980, as cited in Ghassemi et al., 1981). When applied to lemon and orange trees at 11.5 lb a.i./acre, residues were reduced by 83 percent and 94 percent, respectively, by 60 days after treatment; and calculated half-lives were 14 days on orange leaves and 22 days on lemon leaves (Iwata et al., 1979, as cited in Ghassemi et al., 1981). Dissipation rates 8 days after treatment were 81 to 88 percent for spinach and 82 to 85 percent for chicory. Tilden and van Middelem (1970, as cited in Ghassemi et al., 1981) reported that the rate of dissipation of carbaryl on plants appears to be independent of the initial concentration. The following allowable and actual carbaryl residues were reported for citrus and soybeans: (1) 10 ppm residues were allowable for citrus, and 2 to 8 ppm were found 5 days after treatment (1 lb/100 gal); and (2) 5 ppm residues are allowable for soybeans with 0.96 ppm found 38 days after application (1 to 2 lb a.i./acre) (Clement Associates, 1978). In summary, although dissipation rates of surface residues do not vary according to initial concentrations, the proposed application rate of 0.5 lb a.i./acre (8 oz a.i./acre) of carbaryl for the spruce budworm control program is lower than any of those reported in the above studies. Therefore, original residues (in ppm) should be lower than those reported.

Small amounts of carbaryl may be absorbed by roots and foliage and distributed into plants (EPA, 1984). Higher plants have been found to produce some metabolites that remain in the plant tissue and that cannot be removed by the usual extraction procedures (Casida and Lykken, 1969; Dorough and Wiggins, 1969, as cited in Dobroski, 1985). Injection of carbaryl into bean plants led to production of water-soluble compounds that were stable within the plant (Kuhr and Casida, 1967, as cited in Dobroski, 1985). Studies on bean and cotton plants showed carbaryl to have a 3- to 7-day half-life (Dorough et al., 1963, as cited in Dobroski, 1985). The plant systems responsible for these changes may be enzymatic or nonenzymatic and may catalyze hydrolysis of the carbamate (Casida, 1963, as cited in Dobroski, 1985).

Although a portion of the metabolites produced in higher plants is water soluble and may enter the body of animals when the plants are eaten, these soluble metabolites are quickly eliminated (for example, more than 90 percent is eliminated after 96 hours in rats) by way of the urine and feces (Casida and Lykken, 1969; Dorough and Wiggins, 1969, both as cited in Dobroski, 1985). Of six known higher plant metabolites administered to rats, five were less toxic than carbaryl. The remaining metabolite was more toxic than carbaryl, but it was noted that the metabolite is produced only by a minor metabolic pathway in plants (Wiggins et al., 1970, as cited in Dobroski, 1985).

Carbaryl is nontoxic to most plants when applied at label rates (Amer, 1965, as cited in Dobroski, 1985). Carbaryl has been found to injure Boston ivy, Virginia creeper, and maidenhair fern (Union Carbide, 1982), as well as pears, watermelons, and some types of apples (Thomson, 1979). Minor stunting of conifer seedlings also has been observed (Sutherland et al., 1977, as cited in Dobroski, 1985), and retarded germination of grasses may result from excess dosages of carbaryl (Thomson, 1979). Carbaryl may induce abnormal cell mitosis and meiosis in root tips, but recovery occurs within 48 hours (Amer and Farrah, 1968; Amer, 1965, both as cited in Dobroski, 1985). Seed viability may be increased because of the fungicidal action of carbaryl (Eid et al., 1971, as cited in Dobroski, 1985).

Biological Uptake

Carbaryl is not subject to significant bioaccumulation in aquatic ecosystems because of its low solubility and low octanol-water partition coefficient (K_{ow} = 230) (Dobroski, 1985). Uptake of carbaryl in fish has been detected, with 95 percent excreted within 8 hours (Tompkins, 1966, as cited in Dobroski, 1985).

Acephate

Chemical and Physical Properties

Acephate is an organophosphate insecticide that is an acetylation product of methamidophos. The chemical name of acephate is O,S-dimethylacetylphosphoramidothioate. (Figure FA-3 shows the structure of acephate.) Its physical and chemical properties are listed in table FA-3 (Lambert, 1985).

Fate in Soil

Half-lives of 3 and 6 days have been reported for acephate by EPA 1987 for aerobic and anaerobic soils, respectively.

Table FA-3—Properties of acephate

Melting point	82-89 °C (technical)
Vapor pressure	2×10^{-6} mm Hg (25 °C)
Solubility in water	65 g/100 mL
Specific gravity	1.046 (2 lb a.i./gal)
Octanol-water coefficient	0.0428
Organic carbon partition coefficient	2.73

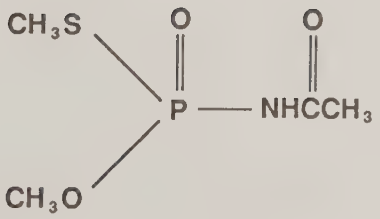


Figure FA-3—Structure of acephate

Microorganisms degrade acephate in the soil. Some soil fungi also can degrade acephate (Liu and Bollag, 1971). No adverse effects on soil organisms have been attributed to acephate (Focht and Joseph, 1974; Dutcher and Sheppard, 1981).

Nonbiological degradation is not important in the removal of acephate from soil. The biological breakdown rate of acephate depends on the soil type and its moisture content. A half-life of 0.5 to 6 days (at 1 ppm of acephate) has been reported (USDA, 1976). During degradation of acephate in soil under a variety of conditions, less than 10 percent of acephate was converted to methamidophos; most was converted directly to innocuous salts.

A soil adsorption coefficient (Kd) of 4.24 has been reported (Curley and Donohue, 1986). Because of its high solubility (65 g/100 mL) and low adsorption to soil materials, acephate is susceptible to leaching in the soil zone under some conditions. Due to its rapid leaching behavior, it has the potential for groundwater contamination (EPA, 1985). Acephate is quite mobile when present. Most acephate breaks down into immobile degradation products before significant transport, even under high rainfall conditions (Chevron, 1973).

Fate in Air

Acephate has low volatility (equilibrium concentration of 2 ppb). Ambient air tests and photolysis experiments, summarized in Lambert (1985), indicate that it is not transferred to the atmosphere from the ground or plant surfaces. Acephate is also relatively resistant to photolysis and does not degrade at a significant rate upon exposure to sunlight.

Fate in the Aquatic Environment

Acephate breaks down relatively slowly in water. The rate of hydrolysis is affected by temperature, pH, and alkalinity. The half-life in water at pH 7 and approximately 70 °F is about 47 days under laboratory conditions (Etter and Tissier, 1973, as cited in Lambert, 1985).

Acephate is degraded in water by basic hydrolysis. At a pH of 8.2 and a temperature of 20 °C (68 °F), 78 percent of acephate was recovered from solution after 20 days. At 30 °C (86 °F), only 18 percent was recovered after 20 days (Szeto et al., 1979). Under expected spruce budworm control application conditions, basic hydrolysis may be significant in the removal of any acephate that may accidentally reach aquatic environments. Szeto et al. (1979) also found that more than 75 percent of applied acephate remained in natural water samples after 45 days; however, the samples were stored at 9 °C (48 °F), so the experiment shows a minimum degradation rate. Also, the presence of bottom sediments in natural waters more than doubled the degradation rates. Field application to surface waters resulted in higher degradation rates. In natural bodies of water, degradation is accelerated by breakdown in aquatic vegetation and microorganisms in sediment. A half-life of 3 to 15 days was reported for ponds in Florida and Iowa treated with 0.1 ppm of acephate (Chevron, 1973). Half-lives ranged from 1 to 3 days in the bottom sediments.

Controlled release of acephate into a flowing creek in British Columbia at 1 ppm was monitored to determine the fate of acephate in natural waters (Hussain and Oloffs, 1980). Acephate concentrations of 1.1 ppm were detected 150 meters downstream during the release of acephate, and levels decreased to 40 ppb within 1 hour of the end of acephate release. At a distance of 2,000 meters downstream, acephate levels peaked at 160 ppb after 8 hours and dropped to 2.7 ppb after 96 hours. No methamidophos was detected in the waters. Acephate and methamidophos dropped to trace levels in sediments after 2 days.

The neutral or alkaline waters typical of the West and the microorganisms present in sediments and vegetation of aquatic environments would be expected to cause relatively rapid degradation rates of acephate.

Fate in Plants

Residue levels based on chemical analyses were reported as part of a tussock moth control program in Canada (Szeto et al., 1979). For an aerial application rate of 1.12 kg/ha (1.0 lb a.i./acre), decay half-lives in the range of 3 to 6 days were found with no detectable concentrations of acephate or its metabolite methamidophos after 60 days. The vertical distribution of acephate residues was highest in the tree crown area and lowest near the ground. The application rate of this study is considerably higher than the 0.094 lb

a.i./acre (1.5 oz a.i./acre) acephate proposed for the spruce budworm control program.

The degradation of acephate on plants is thought to follow a common pattern. The fraction of insecticide not absorbed by plant tissue immediately upon application is subject to washoff, other degradation mechanisms, transport from the plant, and chemical/microbiological breakdown (Robertson and Boeller, 1979, as cited in Lambert, 1985). Dislodgeable residues have been found to have a half-life of 24 hours on plant surfaces (EPA, 1987). From the fraction of insecticide absorbed by the plant, 5 to 10 percent is metabolically transformed to methamidophos. Both the remaining acephate and methamidophos are metabolically degraded over time to innocuous salts (USDA, 1976).

Acephate has low or no phytotoxicity for ornamental and tropical plants at proposed application rates. Application is not recommended for American elm, flowering crabapple, sugar maple, cottonwood, or huckleberry (Thomson, 1979). Acephate is toxic to pine seeds and inhibits germination of white spruce and pine seeds, but it increases germination of yellow birch.

Bioaccumulation

Acephate has a very low potential for bioaccumulation. The octanol/water partition coefficient is 0.04 (Larson, 1975, as cited in Lambert, 1985).

A study in which acephate was injected into a stream showed that fish and insect larvae demonstrated both uptake of acephate and conversion of acephate to methamidophos. Fish uptake of acephate was approximately 1 to 4 percent of the total acephate in the stream. Approximately 4 to 8 percent of that was converted to methamidophos. By 1 day after injection of acephate, both acephate and methamidophos were cleared from fish tissue. Similarly, insect larvae demonstrated acephate uptake (17 percent of water concentration) and conversion to methamidophos (63 percent of tissue acephate concentration). Tissue levels of acephate and methamidophos were below detection levels 3 hours after termination of acephate release into the stream. The conclusion of the study was that acephate applied in the low ppm level to a natural stream would not be persistent in the water, sediments, or organisms beyond 1 to 4 days, that the levels of acephate and methamidophos encountered would not be bioaccumulated (although they would show uptake in fish and insect larvae), and that acephate would not be acutely toxic to stream organisms (Hussain and Oloffs, 1980; Geen et al., 1981, as cited in Lambert, 1985).

Studies using food chain organisms in model ecosystems containing algae, daphnids, emergent plants, insects, and mosquitofish concluded that residues of acephate and its metabolites were not persistent and did not biomagnify along the food chain or accumulate in any ecosystem component. Acephate residues were found only in the model ecosystem water. Metabolic fragments were found incorporated into various tissues, and no acephate residues were detected in fish tissues (Booth, 1975, as cited in Lambert, 1985; USDA, 1976).

Bluegill were continuously exposed to 0.01 and 1.0 mg/L acephate for 35 days. A concentration 10 times as high of acephate residues in their tissue occurred as long as exposure occurred. This uptake followed a dose-response relationship in which tissue levels were proportional to environmental levels of acephate in their water. Upon transfer to uncontaminated water, fish exposed to both levels of acephate eliminated more than 50 percent from their edible portions within 3 days. It was concluded that this level of bioaccumulation was minimal and posed no serious threat to the food chain (USDA, 1976).

A study by Hall and Kole (1980, as cited in Lambert, 1985) showed that, with normal application rates of acephate, bioaccumulation by some amphibians may occur that could threaten other nontarget organisms. Another study using tadpoles indicated that acephate did not bioaccumulate to levels that threatened mallard ducklings (Lyons et al., 1976, as cited in Lambert, 1985). Tadpoles accumulated acephate in their body tissues but only to concentrations approximately equal to ambient levels. The authors estimated that, at maximum body concentrations anticipated from normal application rates, an adult mallard would have to consume 4,700,000 tadpoles to reach lethal levels. This does not rule out possible sublethal effects, such as changes in cholinesterase activity, but it does indicate a wide margin of safety to certain predators of tadpoles.

Methamiphodos

Physical and Chemical Properties

Methamidophos is a transformation product and metabolite of acephate. It is also a manufactured organophosphate insecticide with the trade name Monitor. The chemical name is O,S-dimethyl phosphoramidothioate. Its chemical structure is shown in figure FA-4. Table FA-4 lists its chemical and physical properties.

Fate in Soil

Less than 10 percent of acephate residues are present in soil as methamidophos at any one time (EPA, 1987). Methamidophos degrades rapidly in soil with half-lives of 2 to 12 days in silt, loam, and sandy loam soils (EPA, 1981). At higher initial concentration (20 ppm), degradation was still fairly rapid in a sandy loam soil with a half-life of 10 to 12 days at 24 °C (Tucker, 1972a, as cited in EPA, 1981). Methamidophos is expected to be moderately mobile to very mobile in most types of soils (EPA, 1981).

Fate in Air

No information is available on the transformation of acephate to methamidophos in air. See the discussion on acephate for information on fate.

Fate in the Aquatic Environment

Some fraction of acephate may be transformed to methamidophos in aquatic environments; however, no information is available on the rate or extent of this conversion (Lambert, 1985). Methamidophos, like acephate, is degraded by basic hydrolysis and has a similar half-life.

Fate in Plants

The initial half-life of methamidophos residues on tomato plants is 7 to 10 days (FDA, 1980). After this initial decline of residues, the rate of decline slows to a half-life of about 6 weeks.

Bioaccumulation

Uptake of acephate by fish is approximately 1 to 4 percent of stream concentrations, with approximately 4 to 8 percent being converted to methamidophos after uptake. Aquatic insect larvae showed higher uptake rates (17 percent) and higher conversion rates (63 percent) (Lambert, 1985).

Studies with mammals have shown transformation of acephate to methamidophos in the gut at levels of 0.6 to 1.6 percent (EPA, 1987). Methamidophos is rapidly eliminated in the breath and urine. Goats given 3.75 mg methamidophos daily produced milk with a concentration of 0.003 ppm of parent methamidophos.

Bacillus Thuringiensis

Degradation of *B.t.* spores and crystals (that is, reduction in the number of viable spores) is attributable to solar radiation, temperature, and vapor pressure deficits (Leonge et al., 1980, as cited in Sassaman, 1987). Vegetative cells, on the other hand, are subject to the bactericidal effects of various juices and extracts of many plants (Forsberg et al., 1976, as cited in Sassaman, 1987). The persistence of vegetative cells of *B.t.*, as well as of activity of the various toxic entities of *B.t.*, is strongly dependent on the specific nature of the formulation used and on various environmental parameters, such as sunlight, humidity, and soil conditions. Viable spores last from a few days to weeks depending upon environmental conditions (Sassaman, 1987).

Table FA-4—Properties of methamidophos

Melting point	39-41 °C (for pure compound)
Vapor pressure	1 x 10^{-4} mm Hg (20 °C)
Solubility	Miscible with water and alcohol; 1% in kerosene; 10% in benzene or xylene
Specific gravity	1.31 for melted solid

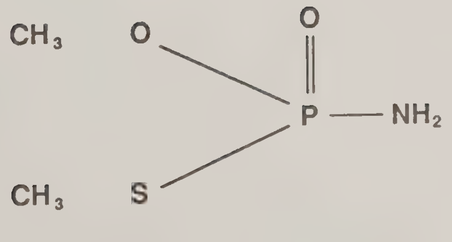


Figure FA-4—Structure of methamidophos

Fate in Soil

Persistence of *B.t.* in soils was reviewed by Forsberg et al. (1976, as cited in Sassaman, 1987). *B.t.* formulations appear to be moderately persistent.

Forsberg et al. (1976, as cited in Sassaman, 1987) reported a 1967 study by Igroffo and Graham in which there was a 90-percent reduction in spore count after 4 months for Bakthane® L-69 (75 x 10^9 spores/g) applied to soil that was exposed to the atmosphere and to 7.28 inches of rainfall. Saleh et al. (1970, as cited in Sassaman, 1987) treated various soils with Thuricide® T (liquid emulsion of 30 x 10^9 spores/g) and with Biotrol® BTB wettable powder (specific activity not provided). They reported recovery of 7,800 to 170,000 spores/g of soil from silty clay and from two silt loams up to 40 days after application. In laboratory soil studies, these authors reported that *B.t.* spores germinated and exhibited population growth in organically amended soils, but in low pH (5.2) soil that has not been been organically amended, the spores germinated while the vegetative cells died.

Fate in Air

Little data are available on the behavior and fate of *B.t.* in the atmosphere. Smirnoff et al. (1973, as cited in Sassaman, 1987) reported persistence of *B.t.* in the air for as long as 17 days after aerial application of *B.t.* (Thuricide® HPC) to a mixed coniferous forest (specific details of amounts and concentration were not provided).

Fate in Water

There are no reports in the literature about the behavior and fate of *B.t.* formulation and of specific toxins, such as the delta-endotoxin, in aquatic systems. Buckner et al. (1974, as cited in Sassaman, 1987) reported that river water, sampled 30 minutes after a 2,500 acre watershed had been treated with 4 billion international units (BIU)/ha of Thuricide® 16 B, contained 1,730 spores/mL. Analysis of the water 30 days after application revealed no presence of *B.t.* spores. Buckner et al. (1974, as cited in Sassaman, 1987) reported *B.t.* concentrations of 22,800 spores/mL following a spray over water. After refrigeration in darkness for 2 months, 7,800 spores/mL were cultured from the same water.

Fate in Plants

The primary concern addressed by most of the available literature on *B.t.* fate in plants is the potential loss of insecticidal activity of the formulations as a result of bactericidal action of the plant fluids (Sassaman, 1987). Forsberg et al. (1976, as cited in Sassaman, 1987) have reviewed the literature on the effects of plant-derived bactericidal chemicals on *B.t.* Smirnoff (1967, as cited in Sassaman, 1987) tested the effects of volatile substances from the crushed foliage of 34 species of plants. He reported that the effects on viability of the bacteria varied among different varieties of *B.t.* and between cells and spores of each variety, with the vegetative cells generally more sensitive to the plant bactericidal chemicals than were the spores.

Pinnock et al. (1971, 1974, and 1975, all as cited in Sassaman, 1987) reported a series of studies on the fate of *B.t.* formulations after appplication to various plants. Following application of Thuricide® 90 TS to oak trees in an unspecified concentration, the viable-spore half-life was determined to be 3.9 days in a cool, moist climate and 7.7 days in a hot, dry climate. Biotrol® BTB 183 dust and wettable powder applied to oak trees in a hot, dry climate had viable spore half-lives of 22.7 days and less than 1 day, respectively. Following application of Amdal® (Dipel® WP was fomerly marketed as Amdal® *B.t.* wettable powder), Biotrol®, and two formulations of Thuricide®, a two-phase loss in viability was reported, with half-lives of 0.58 to 1.85 days for days 0 to 3 and of 1.20 and 2.66 days for days 3 to 7. When Dipel® was applied to the point of runoff to four species of trees (California live oak, red bud, eucalyptus, and walnut), the viable spore half-lives ranged from 0.38 to 0.90 days. Deposition of the spores was not uniform on all tree species, and it was speculated that specific characteristics of tree morphology may have affected the patterns of initial spore deposition and subsequent decrease in viability of the *B.t.* spores (Sassaman, 1987).

Angus et al. (1970, as cited in Sassaman, 1987) monitored the numbers of viable spores of *B.t.* following aerial application of Thuricide® 90 TS to a mixed balsam fir, spruce, and deciduous forest and 0.6 to 1.4 quarts of formulation (specific activity not given/acre). They reported that only 15 percent of the spores were viable 24 hours after application and only 5 percent were viable 72 hours after application.

Hamlen and Henley (1976, as cited in Sassaman, 1987) applied Dipel® wettable powder or Thuricide® HP at 1 or 2 lb a.i./100 gal of final spray volume once a week for 4 weeks to 10 species of tropical foliage plants. Neither formulation was reported to have any phytotoxic effects. Engelhard (1972, as cited in Sassaman, 1987) reported no effects on the flower quality of chrysanthemums treated with 2 or 4 quarts of Thuricide® 57-428 TC 90 in 100 gallons of water, at 66.2 °F (19 °C) or at 85.1 °F (29.5 °C), with either 2 or 4 hours drying rate.

Petroleum Distillates

Physical and Chemical Properties

Diesel oil and kerosene are products of the distillation of raw petroleum (crude oil). Petroleum distillates are fractions of crude oil obtained from refinery distillation processes. These distillates include materials such as aviation fuels, gasoline, lubricating oils, petroleum jelly, wax, and asphalt.

Petroleum Distillation

Petroleum or crude oil consists of hydrocarbons (compounds containing primarily carbon and hydrogen) and to a much lesser degree compounds containing oxygen, nitrogen, sulphur, and other elements. Crude oils are composed of 84 to 87 percent carbon by weight, 11 to 14 percent hydrogen, 0.06 to 2 percent sulphur, 0.1 to 2.0 percent nitrogen, and 0.1 to 2 percent oxygen (Horne, 1978).

Hydrocarbon compounds are divided into two major classes based on structure: the aliphatics and the aromatics (Morrison and Boyd, 1974). (See table FA-5.) Aliphatic hydrocarbons include the alkanes, which have single (saturated) carbon-carbon (C-C) bonds and the more reactive alkenes and alkynes, which have double or triple (unsaturated) C-C bonds, respectively. These compounds all have an open-chain structure. The aliphatic group also includes the cyclic aliphatic, or alicyclic, hydrocarbons. These compounds include cyclic or ring compounds formed from the open-chain alkanes, alkenes, or alkynes.

The aromatic group of hydrocarbons includes benzene and those compounds that have chemical properties similar to benzene. Benzene is a unique cyclic hydrocarbon containing six carbon and six hydrogen atoms. An important characteristic of the benzene ring is that all the C-C bonds are equal in length and are intermediate between single and double bonds (Morrison and Boyd, 1974). This characteristic is called resonance, and the bonds are represented as a circle in the figures in table FA-5.

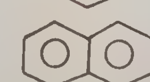
The number of carbon atoms and the C-C bonding present in the substance determine a hydrocarbon compound's physical properties, particularly its melting and boiling points. In general, hydrocarbons having the same number of carbon atoms melt and boil at lower temperatures when they have single C-C bonds than when double or triple C-C bonds are present. In hydrocarbons with the same type of C-C bonds, those with fewer carbon atoms melt and boil at lower temperatures than those with more carbon atoms. The simplest hydrocarbon, methane (CH_4), is a gas at room temperature, while gasoline (C_6H_{14} to $C_{12}H_{26}$) is a liquid.

Routh et al. (1971) describe the fractional distillation of petroleum obtained from oil wells. The separation of the various fractions (gases, gasoline, kerosene, fuel oil, lubricating oil, and the like.) depends on the boiling range of the hydrocarbons that constitute crude oil. Figure FA-5 illustrates the separation of crude oil into relatively distinct fractions based on boiling range. Hydrocarbons with fewer carbon atoms, such as gasoline, boil and are recovered by condensation at lower temperatures than kerosene or fuel oil. The boiling ranges of diesel oil and kerosene are shown in Figure FA-5 for comparison with the other crude oil fractions.

Diesel oil and kerosene have similar properties and characteristics. Table FA-6 lists the chemical and physical properties of diesel oil and kerosene. Diesel oil is composed of molecules ranging from 10 to 25 carbons, with a flash point of approximately 85 °C (DOE, 1983). Kerosene consists of molecules with 12 to 15 carbon atoms, which are predominantly n-alkanes and monocycloalkanes (Routh et al., 1971; Speight, 1980). Kerosene has a flashpoint of 65.6 to 82.2 °C (NLM, 1987). While kerosene's composition differs from that of diesel oil, it is often grouped with diesel oil because its boiling range and its carbon number range fall within those of diesel oil (figure FA-5).

Crude oil can be separated into various groups of hydrocarbons according to different boiling ranges by the process of straight-run distillation. Products of this distillation process include naphtha, kerosene, light fuel

Table FA-5—Hydrocarbon classes and examples

Class	Characteristic Carbon-Bonding	Example Hydrocarbons	Chemical Formula	Melting Point (°C)	Boiling Point (°C)
Alkanes	Open chain of C-C single bonds, saturated	Propane	$CH_3CH_2CH_3$	-187	-42
		1-Hexane	$Ch_3(CH_2)_4CH_3$	-94	+69
Alkenes	Open chain of C=C double bonds, unaturated	Propylene	$CH_3CH{=}CH_2$	-185	-48
		1-Hexene	$CH_3(CH_2)_3CH{=}CH_2$	-140	+64
Alkynes (Acetylenes)	Open chanin of C=C triple bonds, unsaturated	Propyne	$CH_3C{=}CH$	-103	-23
		1-Hexyne	$CH_3(CH_2)_3C{=}CH$	-132	+71
Cycloalkanes	Ring of C-C saturated bonds	Cyclopropane	CH_2-CH_2 / CH_2	NA	NA
		Cyclohexane		NA	NA
Cycloalkenes	Ring with at least 1 C=C double bond	Cyclopropene	CH=CH / CH_2	NA	NA
		Cyclohexene		-104	+83
Aromatics	Benzene ring structure, which includes 6 carbon and 6 hydrogen atoms and equal bond length	Benzene		+6	+80
		Napthalene		+80	+218

Source: Routh et al., 1971.
NA = Not available.

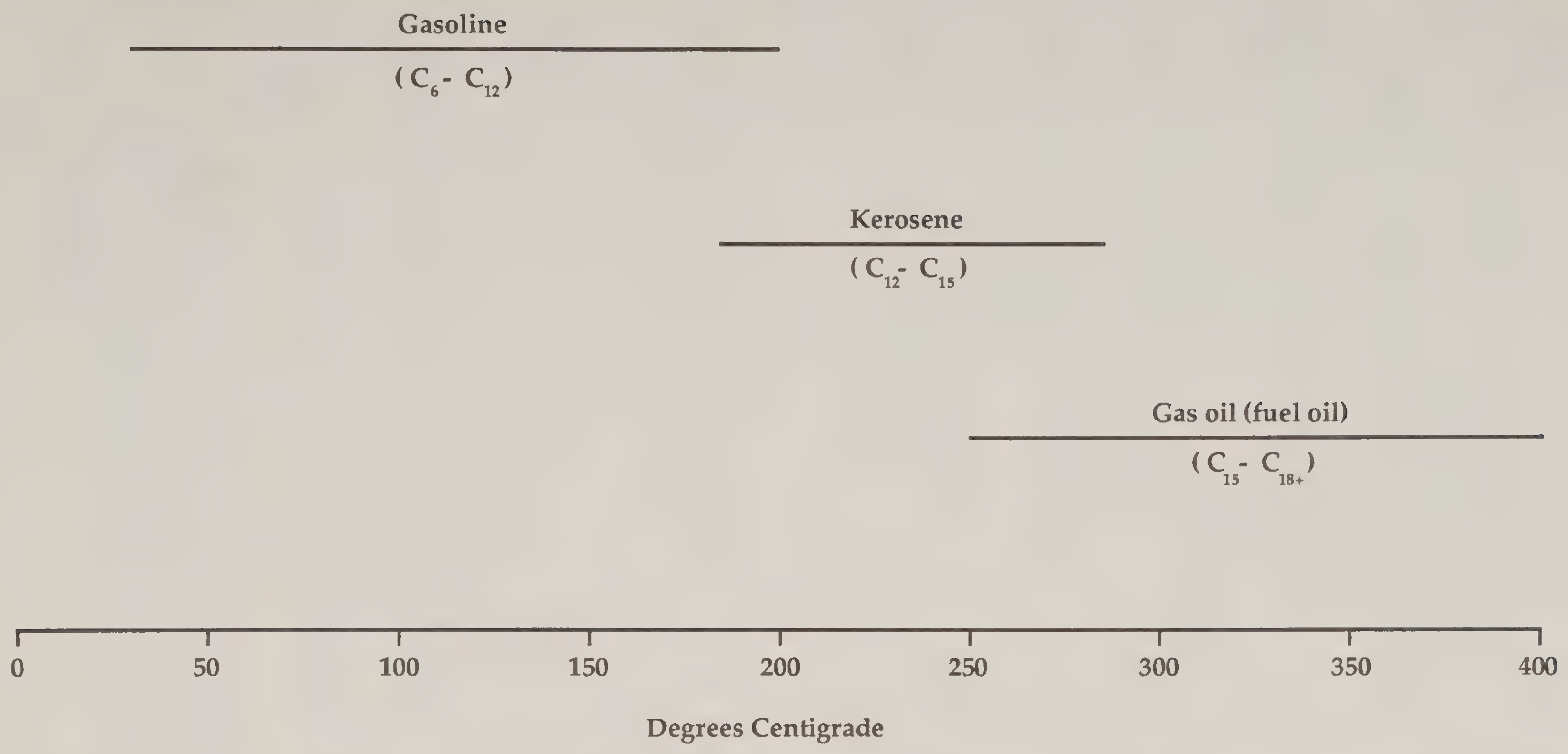


Figure FA-5—Boiling range and range of number of carbon atoms in crude oil distillation products
Source: Routh et al., 1971.

Table FA-6—Physical and chemical properties of diesel oil and kerosene

Property	Diesel oil	Kerosene
Number of carbon atoms	10-25	12-15
Aromatic composition	30-35%	15-20%
Physical state	Oily liquid	Mobile, oily liquid
Color	--	pale yellow or water-white; characteristic, slightly disagreeable
Odor	--	
Boiling range	175-370 °C	175-325 °C
Flash point	85 °C	66-82 °C
Density	0.82 g/mL	0.80 g/mL
Vapor pressure	2.07 mmHg (40 °C)	--
Vapor density	--	4.5
Solubility		
Water	Insoluble	Insoluble
Alcohol	Miscible	Miscible
Other petroleum solvents	Miscible	Miscible
Organic carbon partition coefficient (octanol)	5500	5500

Sources: NLM, 1987; ITII, 1976; DOE, 1983; Routh et al., 1971; Bingham et al., 1979.

oil, diesel fuel, and gas oil (Bingham et al., 1979). These products can be further refined by using heat in a process known as "cracking." Cracking converts large alkanes into smaller alkanes and alkenes (Morrison and Boyd, 1974).

Diesel Oil

Diesel oil, usually a straight-run crude-oil distillation product, is a complex mixture of hydrocarbons containing approximately 10 to 25 carbon atoms per molecule (Neumann et al., 1981). Some of the chemical and physical properties of diesel oil are listed in table FA-6. Diesel oil has a boiling range of 175 to 370 °C. Although diesel oil generally is not miscible with water, certain alcohols, aromatics, and phenols in diesel oil are water soluble (DOE, 1983).

Table FA-7 shows the approximate composition of diesel oil. Normal paraffins are straight-chain structures referred to as n-alkanes; they are the simplest hydrocarbons. The lower n-paraffins form a minor component of diesel oil. Some n-paraffins are normal pentane, octane, and dodecane.

Isoparaffins are branched-chain compounds, commonly referred to as isoalkanes. Theoretically, the branches could be several carbon linkages long, but the isoparaffins in diesel oil are predominantly those with single carbon atom (methyl) branches. Some commonly occurring isoparaffins are isopentane, phytane, and pristane.

Naphthenes are often referred to as cycloparaffins or cycloalkanes. Naphthenes are compounds usually made up of cyclopentane and cyclohexane subunits (having five and six carbon atoms, respectively, in a ring). Up to five rings may be joined together (or condensed) in the more complex molecules. Some naphthenes are cyclohexane, decalin, and fichtelite.

True aromatics contain only aromatic rings and side chains. They occur in diesel oil in various structures ranging from one to five aromatic rings. If more than one ring is present, the aromatics are nearly always condensed and have arrangements similar to those in the naphthenes. Some aromatics are benzene, toluene, trimethylnaphthalene, and pyrene. Figure FA-6 shows some structural formulas of diesel oil components.

Kerosene

Kerosene is a straight-run petroleum distillation fraction (NLM, 1987). It is composed of hydrocarbons containing 12 to 15 carbon atoms per molecule (Routh et al., 1971; Gruse and Stevens, 1960). Some of the chemical and physical properties of kerosene are listed in table FA-6. The boiling range of kerosene is 175 to 325 °C. It is insoluble in water and is miscible in alcohol (NLM, 1987; ITII, 1976). The Chemical Abstracts Registry (CAS) number is 8008-20-6 (NLM, 1987).

The approximate composition of kerosene from Ponca Petroleum of Oklahoma is shown in table FA-8. Although the kerosene constituents are predominantly saturated materials, there are also unsaturated compounds. Dicycloparaffins (naphthenes) also occur in substantial amounts in kerosene. Other hydrocarbons with aromatic and cycloparaffin rings in the same molecule, such as substituted indanes, occur in kerosene. The predominant structure of the dinuclear aromatics appears to be that in which the aromatic rings are condensed, such as naphthalene; the isolated two-ring compounds, such as biphenyl, are only present in traces if at all (Speight, 1980). Kerosene contains no nitrogen, sulfur, or oxygen compounds (Butt, 1986).

Figure FA-6 shows structural formulas for some components of kerosene.

Fate in Soil

The fate of diesel oil in the soil environment depends on the physical and chemical properties of the diesel oil components. The aliphatic, unsaturated hydrocarbons, which compose the bulk of diesel oil, are insoluble and are preferentially adsorbed to soil minerals and organic matter. This fraction is considered relatively immobile. Degradation occurs through biological activity of soil microorganisms. The aromatic fractions of diesel oil and kerosene are more water soluble and may be leached in small amounts from the soil column into ground water (DOE, 1983).

Table FA-7—Estimated percent compositions of diesel oil and kerosene[a]

Compound	Kerosene	Diesel oil
Normal paraffins (N-alkanes)	5.6	11.1
Isoparaffins (isoalkanes)	11.1	18.5
Napthenes (cycloparaffins or cycloalkanes)	46.3	50.0
Aromatics	33.3	20.4
Nitrogen, sulfur, and oxygen compounds	3.7	0

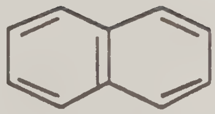
[a]Estimated from Butt, 1986.

Table FA-8—Composition of kerosene from Ponca Petroleum, Oklahoma, U.S.A.

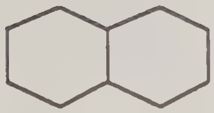
Hydrocarbon Type	Volume percent
Alkanes (paraffins)	
Normal	23
Branched	16
Monocyclo-	32
Dicyclo-	11
Tricyclo-	0
Aromatics	
Mononuclear[a]	15
Dinuclear	3

[a]Includes both alkylbenzenes and aromatic-cycloparaffin types.
Source: Speight, 1980.

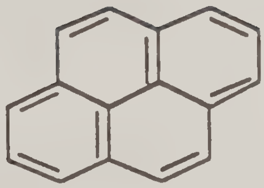
Naphthalene ($C_{10}H_8$)



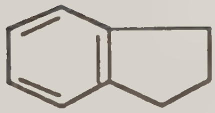
Decalin ($C_{10}H_{18}$)



Pyrene ($C_{16}H_{10}$)



Indane (C_9H_{10})



n-Dodecane ($C_{12}H_{26}$)

Figure FA-6—Structural formulas of some kerosenes and diesel oil constituents

As the dominant component of diesel oil, the aliphatic hydrocarbons determine the fate of most of the diesel oil released into the environment. Octane may be considered representative of this group of compounds. It is among the smaller molecules found in the aliphatic hydrocarbons, and its properties give a conservative estimate of the mobility of similar components of diesel oil. Octane has a low water solubility (0.66 ppm at 25 °C) and adsorbs readily to soils (Kd = 110, calculated from Lyman et al., 1981). These properties result in octane being relatively immobile in soils, where it is subject to biodegradation (rate constant = 0.11 per day) (Ladd, 1956). At application rates of a few pounds per acre, the aliphatic hydrocarbons have little potential for leaching from soils before significant biodegradation occurs.

The aromatic fractions of diesel oil include benzene, toluene, methylbenzenes, and methylnapthalenes. In general, these compounds are relatively soluble in water. In a preparation of seawater and diesel oil at a ratio of 9:1 (volume:volume), 6.28 mg/L of the diesel oil was soluble, mainly as aromatic hydrocarbons (Anderson, 1975). Benzene has a solubility of 1,780 mg/L (at 25 °C). Toluene has a solubility in water of 470 to 515 mg/L (Buikema and Hendricks, 1980). Adsorption of benzene by soils is moderate (Kd approximately 1.3, calculated from Mabey et al., 1982). Adsorption of toluene has been estimated to be approximately five times greater than that of benzene.

Aromatics that are water soluble and have low capacity for adsorption are likely to leach downward in the soil column. Aromatics undergo degradation at a lower rate than the aliphatics. The half-life for benzene is less than 1 month (Cogley et al., 1975, as cited in Buikema and Hendricks, 1980).

Diesel oil evaporates very slowly when spilled on the soil. Losses from the soil result primarily from microbial degradation. Different fractions of the oil behave differently. The nonaromatic hydrocarbons are usually adsorbed to soils and slowly evaporate or undergo biological degradation; they do not leach readily. Soluble aromatics, such as alkylated benzenes and naphthalenes, tend to be volatile but also tend to remain more stable and are mobile in the soil column (DOE, 1983).

In the event of a spill, leaching hazard to a ground-water supply at a given depth below the soil surface depends upon the porosity of the soil and a characteristic of the petroleum product called its "residual saturation" (Davis et al., 1972). Soil porosity ranges from 25 to 50 percent in gravels and sands to 35 to 70 percent in silts and clays (Law Engineering Testing Company, 1982). Residual saturation, determined by the product's viscosity, is a measure of the tendency of the product to adhere to soil particles rather than to continue to move downward in soil under the force of gravity.

Residual saturation in petroleum products ranges from 0.10 for gasoline to 0.20 for heavy fuel oil. Diesel oil has a residual saturation of about 0.15.

Davis et al. (1972) present an equation for determining the volume of soil required to immobilize an oil spill based on the product's residual saturation as follows:

$$V_{soil} = \frac{0.20 \times V_{oil}}{P \times S_R}$$

where:

V_{soil} - is the volume of soil in cubic yards required to immobilize the spill

V_{oil} - is the volume of the oil product in barrels (1 barrel = 42 gallons)

P - is the soil porosity (fraction of pore space)

S_R - is the product's residual saturation

This spill equation can be applied to determine the possibility of ground-water contamination from a routine aerial application. Assuming an application rate for diesel oil of 20 gallons per acre and a soil porosity of 30

percent, the soil volume required for diesel oil would be as follows:

$$\frac{0.20 \times (20/42)}{0.30 \times 0.15} = 2 \text{ cubic yards}$$

Assuming an application rate for kerosene of 0.015 gallons per acre as an inert in pesticide formulation, the required soil volume would be as follows:

$$\frac{0.20 \times (0.015/42)}{0.30 \times 0.13} = 0.0018 \text{ cubic yards}$$

One acre of soil contains 134.4 cubic yards of soil in the top 1 inch. Therefore, at the application rates described above, neither product is likely to move down through the soil below the top inch unless rain follows immediately after spraying. Therefore, ground-water contamination immediately following a spray operation is not likely to occur. However, if a spill of the same 20 gallons of diesel oil were to occur in an area where the water table is close to the surface, there is a possibility of contamination. Proper spill cleanup procedures should begin immediately.

Areas most susceptible to ground-water contamination would be those with low porosity soils (gravels and sands), high water tables (that is, close to the soil surface), and low populations of oil-degrading microorganisms.

The potential for runoff of diesel oil from soil is low based on the strong adsorption of octane to soils (Kd = 110, calculated from Lyman et al., 1981) and its rapid biodegradation (half-life = 6.3 days, based on a rate constant of 0.11, Ladd, 1956). Immediately after a heavy rainfall diesel oil was not detected (detection limit = 1 mg/L) in a stream adjacent to a site treated at 15 to 20 gallons per acre (Thofern, 1962, as cited in DOE, 1983).

Fate in Air

Aerial application of diesel oil at canopy height in forested areas could present a problem by evaporating while descending from the spray boom: diesel is volatile because of a relatively high aromatic content. Evaporation reduces droplet size, thus contributing to drift potential. Evaporation of diesel oil would be much less than that of water, which is the predominant alternative carrier used in pesticide formulations.

Because of the relatively high volatility of diesel oil (2.07 mm Hg at 40 °C) and its aromatic constituents (95.2 mm Hg at 25 °C for benzene), transfer to the atmospheric environment from evaporation of spray droplets and evaporation from plant surfaces is probable. There is a slight possibility that diesel oil or kerosene might produce flammable vapors that could be hazardous, but these vapors should not be a problem in forestry applications because the amounts sprayed are relatively low and they are not applied in a confined space.

Because of the hazards associated with the production of vapors from diesel oil and kerosene, handling and use should occur only in well-ventilated areas.

Fate in Water

Studies reported by DOE (1983) indicate that diesel oil applied to water first forms a partial film on the surface water. A portion of the acutely toxic volatile compounds may quickly evaporate from the film, while the remaining portion is adsorbed to particulates or is dissolved in water. Photooxidation acting on surface films can generate materials highly toxic to aquatic organisms (DOE, 1983). Surface oil is readily adsorbed on suspended particulates and may settle from the water column to the sediments (DOE, 1983). Blumer (1970, as cited in DOE, 1983) found that No. 2 fuel oil, incorporated into estuarine sediments after a spill, persisted for more than a year and spread in the form of oil-laden sediment beyond the original spill area.

Oil particles in water are decomposed mainly by aerobic microbiological processes (McCauley, 1966, as cited in DOE, 1983). The biochemical oxygen demand (BOD) is approximately 3.1 to 3.5 mg 0_2/mg oil (or about

2,500 to 2,800 mg O_2/mL oil, assuming that the density of diesel oil is about 0.8 g/mL). Water temperature is important in determining the rates of decomposition and sedimentation (DOE, 1983).

The aromatic hydrocarbons are more soluble than the aliphatic compounds (1.78×10^3 mg/L for benzene and 535 mg/L for toluene, both at 25 °C). Some of the aromatics would be volatilized into the atmosphere before reaching surface waters (vapor pressure = 95.2 mm Hg at 25 °C for benzene). The half-life for volatilization of typical aromatics ranges from 2 to 10 days, based on available values for the Henry's law constants for toluene and benzene ($H_c = 6.66 \times 10^{-3}$ atm)(m^3/mol) for toluene, $H_c = 5.5 \times 10^{-3}$ atm (m^3/mol) for benzene (from Mabey et al., 1982)).

Fate in Plants

Diesel oil and kerosene are highly toxic to plants. DOE (1983) reports that diesel oil readily wets plant surfaces and spreads as a thin film over leaf surfaces. Diesel oil penetrates the crowns of grasses where growth originates. It penetrates many other plants through stomata because oil has a very low surface tension and is not barred from penetration as are most aqueous solutions (Van Overbeek and Blondeau, 1954, as cited in DOE, 1983). Diesel oil, therefore, may increase the adsorption by the plant of systemic herbicides.

Numerous workers suggest that an oil coat on leaves and stems will inhibit gas exchange and lead to death, but the data do not support this suggestion (Baker, 1970, as cited in DOE, 1983). Kerosene and diesel fuels are contact herbicides in their own right (California Department of Food and Agriculture, 1978, as cited in DOE, 1983) because of the toxic properties of the more volatile components.

Oil moves into intercellular spaces and in the process may interfere with translocation of metabolic products and nutrients in the plant (Baker, 1970, as cited in DOE, 1983). Oil does not penetrate cells unless the cells are injured (Van Overbeek and Blondeau, 1954, as cited in DOE, 1983). Toxicity varies according to the content of low boiling compounds, alkenes (unsaturated compounds), aromatic compounds, and acids. Phenolic acids and polycyclic aromatics are especially toxic to higher plants at low concentrations because of disruptive effects on cell membranes (Van Overbeek and Blondeau, 1954; Larson et al., 1977, both as cited in DOE, 1983). Chronic injury also results from alkenes (Baker, 1970, as cited in DOE, 1983).

The mechanisms of cell injury and death are not clearly understood. Oil application depresses photosynthetic rates and depresses respiration rates to a lesser extent. As a result, respiration may exceed photosynthesis and lead to cell death (Wedding et al., 1952, as cited in DOE, 1983). Van Overbeek and Blondeau (1954, as cited in DOE, 1983) have described the symptoms of oil toxicity. The earliest symptom is darkening of young leaf tips, presumably because of fluid leakage into intercellular spaces. The darkening spreads to older leaves, and cells begin to lose turgor, resulting in plant drooping. Eventually cell membranes are disrupted, resulting in an increase in cell membrane permeability. Photosynthetic activity drops after chlorophyll is destroyed by bright sunlight. Photosynthesis is inhibited by oil deposition as low as 0.3 to 0.6 mg/cm^2 (leaf surface).

Bioaccumulation

A few constituents of diesel oil have some potential for bioaccumulation. The octanol-water partition coefficients (K_{ow}) are 10,000 for octane, 620 for toluene, and 135 for benzene (Mabey et al., 1982). The bioconcentration factors (BCF's) of these constituents were estimated. Using the K_{ow}'s and the formula by Veith et al. (1979a, as cited in Spacie and Hamelink, 1985), log BCF = 0.76 (log K_{ow})-0.23. The estimated BCF's were 646 for octane, 78 for toluene, and 24 for benzene. A bioconcentration factor of 12.6 has been estimated for benzene by Lyman et al. (1981).

In exposure studies to marine invertebrates, exposure to a 30-percent solution of the water-soluble fraction (about 2 mg/kg hydrocarbons) resulted in maximum tissue concentrations of 10 mg/kg in grass shrimp *Palaemonetes pugio*, with subsequent depuration to less than 0.2 mg/kg in 50 hours (Anderson, 1975). In the same study, the clam *Rangia cuneata* had tissue concentrations of napthalenes of 100 to 150 mg/kg after exposure to 384 mg/L of No. 2 fuel oil in oil-water dispersions with depuration to approximately 0.2 to 0.3 mg/kg after 200 hours in oil-free water. The study revealed that the aquatic invertebrates could expel toxic components of oils from tissues, even after very high exposure levels (Anderson, 1975). The sublethal toxic effects of these levels of exposure were not examined.

Attachment F-B

Procedures for the Selection of Data Sets for Worst Case Risk Analysis: Mutagenicity/Carcinogenicity

Background

The methods for cancer risk analysis using animal data have been reasonably well formulated. However, in the absence of rodent cancer data or with negative rodent cancer data, positive results from *short-term* tests for *genotoxicity* have been used as justification for either (1) questioning the adequacy of the rodent cancer studies, or (2) recommending risk assessments for *heritable mutations* by way of *germ cell damage* in rodents.

The rationale for such a use of short-term assays rests with the close mechanistic and correlative association between carcinogens and mutagens (Brusick, 1987). It also assumes that agents defined by short-term tests as *mutagens* have the potential to induce similar damage in mammalian germ cells and that such damage could be transmitted to successive generations in the form of genetic disease or congenital malformations (Brusick et al., 1981).

Definitions

Often the meaning of technical terms are not universally consistent and, without general agreement as to what they mean, arbitrary use of some terms or phrases may tend to increase confusion surrounding the analysis of a scientific issue. The five terms or phrases in italics in the above section may be defined in several ways. Their meanings in this discussion are as follows:

Short-term tests—submammalian, mammalian *in vitro* cell culture or mammalian somatic cell tests measuring DNA alterations.

Genotoxicity—the process of chemical-induced damage to the DNA of an organism that will produce cell death, mutation, DNA alterations and repair, or cell transformation.

Heritable mutations—mutations that are induced at any germ cell stage in mammalian gametogenesis and that can be transmitted to and expressed in subsequent generations.

Germ cell damage—in rodents, this is measured by very specific types of assays. Germ cell damage may produce lethal or heritable effects; in this discussion, only those effects that are heritable are considered relevant to risk assessment. The two standard tests for assessment of germ cell damage in this context are the mouse specific locus test (SLT) and the mouse heritable translocation test (HTT).

Mutagens—chemicals capable of inducing gene or chromosome damage that is stable and survives cell division. Effects may be in somatic cells or germ cells.

Nature of the Data Encountered in Developing Risk Assessments

The mutation and cancer data configurations of interest are summarized in table FB-1. The selection of a data set for use in making a risk analysis is based on the data most likely to provide the worst case estimate.

Issues and Recommendations

The issues have been formulated as follows:

1. From the data sets shown in table FB-1, how does one support selection of data for the worst case risk?

Table FB-1—Bioassay results and data selection for risk analysis

Rodent cancer studies	Rodent germ cell mutation studies	Selection of data for risk analysis
Positive	Positive	Cancer data
Positive	Negative or no data	Cancer data
Negative or no data	Positive	Mutation data
Negative or inconclusive data	Negative or no data[a]	Estimated from upper bound of high dose cancer data

[a]Short-term tests for genotoxicity show some positive effects.

2. For chemicals with no germ cell mutagenicity studies and inconclusive or negative cancer studies, should positive short-term test results for genotoxicity assays be used as evidence in a worst case analysis that a heritable mutation risk may exist at exposures lower than the maximum tolerated dose (MTD) used to test for cancer?

Recommendations: Issue #1

In the cases where rodent cancer studies have been performed, these data should be used to set the human risk levels unless it can be shown from corresponding rodent germ cell data that statistically significant specific locus mutation or heritable translocation responses occur at comparable or lower exposures.

Rationale

The existing data base for chemicals that have been tested in rodents for carcinogenic as well as heritable mutation effects supports the judgment that carcinogenesis is the more sensitive of the two endpoints. Human cancer and mutational epidemiology information accumulated from atomic bomb survivors in Japan shows clear associations between dose and cancer but no mutations have been found. Radiation is mutagenic in rodents. The data in table FB-2 are used to support the sensitivity argument by comparing the results and effective dose levels for virtually all chemicals that have been tested for heritable germ cell mutation and have corresponding rodent cancer studies. Data from chemicals negative in both bioassay types are not included. Although all compounds listed were found to be carcinogenic, seven were clearly nonmutagenic at the highest dose tested and three were evaluated as inconclusive (no significant effect in the sample size examined). It is important to note that no compounds have been shown to induce heritable germ cell responses in rodents without concomitant carcinogenicity.

Potency comparisons (lowest effective daily dose for mutagenicity vs. tumor dose 50 (TD_{50}) daily dose for carcinogenicity, which is the dose estimated to result in 50 percent tumor-free animals at the end of the study) with chemicals that produced both effects showed that risk to cancer was found at lower average daily dose levels than risk to heritable mutation in all cases and for total cumulative dose for most chemicals. For some nonmutagens, the total applied dose was lower than the cumulative dose needed to achieve a TD_{50}. This is explained by the fact that mutation studies are conducted with single acute exposures and that the total amount of material applied acutely will be less than that which could be applied by repeated exposures of lower doses.

There are many possible explanations for the observations that cancer is the more sensitive endpoint; for example, mammalian gonads are generally protected from the systemic exposures by the blood-gonad barriers. It also appears that the meiotic process associated with germ cell production is extremely effective in eliminating damaged DNA before it becomes part of mature spermatozoa or ova. This is probably accomplished by DNA repair or by selective elimination of damaged cells from the gene pool.

When cumulative exposures from chronic cancer studies (approximately 500 days) are compared to single total doses from mutation studies, a few of the chemicals (cyclophosphamide, methylmethane sulfonate, trenimon) appear to show greater activity for mutation than cancer. These examples are probably not exceptions but represent the bias encountered toward the mutation data. The following points illustrate three aspects of comparisons that would tend to enhance the apparent sensitivity of mutation assays:

Fractionation of Doses. Cancer studies are conducted with low daily doses given chronically while mutation studies are generally conducted with a single acute high dose. Occasionally, multiple dose studies for mutation are performed. When chemicals are tested for mutation using both single acute and subchronic applications, the results are often different.

Fractionated doses for mutation appear to result in a significant drop in mutation. Russell et al. (1982) have shown that 10 x 10 mg/kg doses of ethyl nitrosourea given over 10 weeks gives a much lower mutation frequency than a single dose of 100 mg/kg. Other findings indicate that, for some agents, the results for fractionated doses appear to be additive (Ehling, 1980; Ehling and Neuhauser-Klaus, 1984). In order to make the most conservative comparisons, the cumulative TD_{50} average (mg/kg) daily dose (roughly 500 days for a chronic study) from the rodent cancer studies was compared with either the lowest effective dose for mutagens or the highest dose tested for nonmutagens. Dose rate *differences would tend to bias sensitivity toward the mutation data.*

Table FB-2—Comparison of the carcinogenic and germ cell mutagenicity activities of 20 chemicals

Chemical	Rodent[a]		Total Dose applied (mg/kg)		Most sensitive endpoint[d]	
	Carcinogen	Mutagen	Cancer (ADD)[b]	Mutation[c]	Avd. Daily dose	Total dose
Benzo(a)pyrene	+	-	1000 (2)	5000	C	C
Cyclophosphamide	+	+	3500 (7)	350	C	M
Diethylnitosamine	+	-	10 (.02)	119	C	C
7,12-dimethylbenzanthracene	+	inc.[e]	40 (.08)	10	C	C
Ethylmethane sulfonate	+	+	-	300	?	?
Ethylnitrosourea	+	+	-	250	?	?
Methylmethane sulfonate	+	+	17,500 (35)	20	M	M
Methylnitrosoguanidine	+	inc.	1,000 (2)	50	C	C
Mitomycin C	+	+	.05 (.001)	5	C	C
Procarbazine	+	+	250 (.5)	400	C	C
Propylmethane sulfonate	+	+	-	800	?	?
Triethylene melanine	+	+	-	0.2	?	?
Trenimon	+	+	250 (.5)	0.13	M	M
Nitrogen mustard	+	+	5 (.01)	-	?	?
Captan	+	-	50,000 (100)	3000	C	C
Ethylcarbamate (urethane)	+	-	25,000 (50)	1750	C	C
Hexamethylphosphamide	+	-	-	1989	C	C
Ethylene dibromide	+	inc.	1500 (3)	167	C	C
1,2-Dibromo-3-chloropropane	+	-	2000 (4)	384	C	C
Nitrilotriacetic acid	+	-	112,500 (225)	3000	C	C

[a]Mouse or rat.
[b](ADD) average daily dose required to produce TD_{50} (dose producing tumors in 50 percent of test animals).
[c]In mutation studies, exposures are generally acute; thus, Total Dose = ADD.
[d]C = cancer, M = mutation, ? = data gap.
[e]Inconclusive.

Route of Administration. Most of the mutation assays were performed using intraperitoneal (IP) injection of the test agent. This route of administration is believed to overestimate risk because chemicals that are not readily absorbed from the gastrointestinal tract following ingestion will be active by this route. Chemicals that would readily hydrolyze to nonmutagenic forms under ingestion or gavage routes are also known to produce positive effects by the IP route. None of the cancer studies were conducted using intraperitoneal injection exposure. Chemicals such as nitrosoguanidine, ethylmethane sulfonate, and methylmethane sulfonate would probably not be mutagenic in mice if administered via oral ingestion. *The routes of exposure used would tend to bias sensitivity toward the mutation data.*

Response Parameters. The dose levels used from the cancer studies represent the TD_{50}. The TD_{50} is not necessarily the lowest effective carcinogenic dose; it is used as a means of normalizing responses from different species and study designs. The doses used from positive mutation studies represent the lowest tested dose that produced a statistically significant increase in either specific locus mutation or heritable translocation in mice. Studies defined as negative were of sufficient power to declare a noneffect. Studies defined as inconclusive showed no increase in mutation but had an insufficient sample size to declare the chemical a clear negative. In either of the latter two cases, the dose shown was the highest dose tested. *Comparing the cancer bioassay TD_{50} dose to the lowest effective mutagenic dose would probably tend to bias the sensitivity toward the mutagenicity data.*

Thus, it is not surprising that, for a few selected chemicals, mutation risks may appear greater than cancer risks; however, if these compounds could be compared at the same dose rate and by a relevant route of exposure (oral ingestion or inhalation), it is very likely that the apparent sensitivity of the mutation endpoint would disappear.

Recommendations: Issue #2

Germ cell mutation data can be used for worst case risk analysis only when (1) no rodent cancer studies have been conducted and positive germ cell data (heritable translocation assay or specific locus mutation assay) are available, or (2) rodent cancer studies have been conducted that produced negative results and positive germ cell data are available. Positive short-term test results are insufficient evidence for presumption of germ cell risk.

Rationale

As argued under Issue #1, genotoxins have a higher probability of expressing biological activity as carcinogens rather than as inducers of heritable germ cell effects in rodents (table FB-2). All available data also support the fact that carcinogenic potential in rodents will be exhibited at lower (average daily or cumulative) doses than heritable mutagenicity for mutagenic carcinogens. Consequently, agents tested in rodents at the MTD that fail to elicit an effect as a somatic cell tumorigen are not going to produce heritable effects under similar exposure conditions in the intrinsically more resistant germ cells.

Occasionally, the toxicity data available to calculate worst case risk may consist of chemicals with negative or inconclusive rodent cancer data and positive short-term test results for genotoxicity (excluding positive germ cell responses). The tendency might be to generate a worst case by "assuming" that the short-term studies are adequate evidence that the chemical would induce heritable germ cell effects and therefore should be treated as a mutagen. This is not a supportable assumption based on the rationale supporting the recommendations for Issue #1 and an analysis of how well positive short-term test results predict germ cell mutagenesis in rodents.

Evidence that argues against the presumption that "a chemical that is not carcinogenic in rodents but is positive in short-term tests should be treated as a germ cell mutagen" comes from analyses of the predictivity of short-term genotoxicity assays for concomitant responses in rodent germ cells. Three independent analyses of the concordance values clearly demonstrate that one cannot accurately predict heritable genetic damage in vivo from single short-term assays (ICPEMC Committee 1, 1983; Russell et al., 1984; Bridges and Mendelsohn, 1986). Tables FB-3 and FB-4 give results from the EPA GeneTox data base in which the concordance between individual short-term tests and responses in either the mouse specific locus or the mouse heritable translocation assays are calculated. When the concordance values for any individual comparison are corrected for random assortment, none of the short-term test observed concordance values is statistically significant (Russell et al., 1984). This finding precludes general extrapolation from a positive short-term test response to a presumption of effects in rodent germ cells.

Table FB-3—Performance of various assays relative to specific-locus-test (SLT) results

Assay compared with SLT[a]	Concordance Observed	Concordance Calculated for random assortment[b]
Mouse spot test	91.7	77.8
Unscheduled DNA synthesis in testis	83.3	55.6
Micronucleus test	71.4	50.0
Plant gene mutations	61.5	60.4
Saccharomyces mutation	69.2	69.2
Dominant lethal	66.7	53.3
Drosophila sex-linked recessive lethals	62.5	55.5
Salmonella mutation	64.3	54.1
Sperm anomalies in treated males	66.7	61.1
Neurospora mutation	63.6	63.6
Plant chromosome anomalies	63.6	63.6

[a]Only assays that gave results for at least 20 of the chemical tests by the assays.
[b]On the null hypothesis.

Table FB-4—Performance of various assays relative to heritable-translocation-test (HTT) results

Assay compared with HTT[a]	Concordance: Observed	Concordance: Calculated for random assortment[b]
Unscheduled DNA synthesis in testis	90.9[c]	64.5
Dominant lethal	76.5	64.0
SCE, animal cells, in vitro	91.7	77.8
Sperm anomalies in treated males	91.7	77.8
Drosophila heritable translocations	83.3	70.8
Micronucleus test	80.0	72.0
Salmonella mutation	71.4	65.3
Plant chromosome anomalies	92.3	92.3
Neurospora mutation	90.9	90.9
Drosophila sex-linked recessive lethals	83.3	83.3
Saccharomyces mutation	78.6	78.6
Male germ-cell cytogenetics	50.0	50.0
Host-mediated assay	78.6	80.6
Plant gene mutation	66.7	72.2

[a]Only assays that gave results for at least 20 of the chemical tests by the assays.
[b]On the null hypothesis.
[c]Borderline of significance, P = 0.055.

Source: Adapted by Russell et al. (1984).

Thus, a hope that one can develop a worst case risk analysis for heritable mutation with a compound that is not carcinogenic in rodents but has some positive short-term test results is not supported by the available data. Semianalytical weight-of-evidence approaches considering data from extensive batteries of short-term tests are available and may prove valuable in performing this type of hazard assessment. A better approach to establish a worst case would be to establish the estimated risk from the cancer study assuming an effect at the upper bound of the 95 percent confidence limits. This would provide a suitable conservative worst case assessment for nonthreshold effects. It would also prevent short-term test data from being inappropriately used in risk analysis.

Conclusions

The available data generated from rodent risk assessment assays on chemicals tested for cancer and mutation support the general practice of setting worst case human risks for nonthreshold toxicity on the basis of estimated tumor induction. This practice is not only supported quantitatively by comparing lowest effective doses where both biological endpoints have been induced, but is also supported qualitatively in that:

1. Chemicals that are effective carcinogens in rodent models have not been found to be mutagenic to the germ cells at comparable or even higher exposures.

2. No chemical has produced unequivocal heritable mutation in rodents that is not also carcinogenic and generally at lower exposures.

3. Humans exposed to a genotoxic carcinogen (radiation) showed significant increases in cancer but no evidence of induced germ cell mutation.

Extrapolation of positive responses from short-term nongerm cell mutagenicity studies to a presumption of effect or risk to germ cells is not supported by the available data. Positive short-term tests results should be used to support a presumption of carcinogenic potential.

Short-term assay data sets should be evaluated using a weight-of-evidence approach.

References Cited

Section F1

Ehling, U.H. 1988. Quantification of the genetic risk of environmental mutagens. *Risk Analysis* 8(1):45-57.

Hazelton Laboratories. 1988. Personal communication regarding the costs of toxicity and exposure testing.

National Research Council (NRC). 1983. *Risk Assessment in the Federal Government: Managing the Process.* National Academy Press, Washington, DC.

National Research Council (NRC). 1986. *Drinking Water and Health, Volume 6.* R. D. Thomas, ed. National Academy Press, Washington, DC.

Section F2

Adair, H. M. and G. J. Rich. 1977. Results of 1976 trials with Orthene for *Heliothis* control on cotton. Proceedings of the Beltwide Cotton Producers Conference, pp. 92-93.

American Cyanamid Company. 1986. Technical information Cythian® insecticide Agricultural Division. Wayne, NJ.

American Petroleum Institute. 1983a. 28-day dermal toxicity study in the rabbit, hydrodesulfurized kerosene sample 81-07. API Medical Research Publ. 30-32297. Washington, DC.

American Petroleum Institute. 1983b. Carcinogenic potential of key petroleum products. API Medical Research Publ. 30-31646. Washington, DC.

American Petroleum Institute. 1983c. *Index and Abstracts for Reports and Other Publications.* Medicine and Biological Science Department, American Petroleum Institute. Washington, DC.

Anderson, J. W. 1975. Laboratory studies on the effects of oil on marine organisms: an overview. API Publication No. 4249. American Petroleum Institute, Washington, DC.

Barrett, G. W. 1968. The effects of an acute insecticide stress on a semienclosed grassland ecosystem. *Ecology* 49(6):1019-1035.

Bart, J. 1979. The effects of acephate and Sevin on forest birds. *Journal of Wildlife Management* 43(2):54-549.

Barthel, E. 1981. Increased risk of lung cancer in pesticide-exposed male agricultural workers. *Journal of Toxicology and Environmental Health* 8:1027-1040.

Beck, L. S., D. I. Hepler, and K. L. Hausen. 1982. The acute toxicology of selected petroleum hydrocarbons. In: Macfarland, H. N., C. E. Holdsworth, J. A. MacGregor, R. W. Call, M. L. Kane (eds.) pp. 1-12. *Proceedings of the Symposium ... the Toxicology of Petroleum Hydrocarbons.* American Petroleum Institute. Washington, DC.

Berteau, P. E. and R. E. Chiles. 1978. Studies on the inhalation toxicity of two phosphoramidothioate insecticides to rodents and quail. *Toxicology and Applied Pharmacology* 45(1):232.

Bingham, F., R. P. Trosset, and D. Warshawsky. 1979. Carcinogenic potential of petroleum hydrocarbons. *J. Environmental Pathology and Toxicology* 3:483-563.

Blair, A. and T. Thomas. 1979. Leukemia among Nebraska farmers: a death certificate study. *American Journal of Epidemiology* 110(3):264-273.

Blair, A. 1982. Cancer risks associated with agriculture: epidemiologic evidence. In Fleck, R. and A. Hollaender. 1982. *Genetic Toxicology*. Plenum Publishing Corporation.

Blair, A. and D. White. 1981. Death certificate study among farmers from Wisconsin. *J. NCI* 66(6):1027-1030.

Blair, A. and D. White. 1985. Leukemia cell types and agricultural practices in Nebraska. *Archives of Environmental Health* 40(4):211-214.

Blair, A., D. Grauman, J. Lubin, and J. Fraumeni. 1983. Lung cancer and other causes of death among licensed pesticide applicators. *J. NCI* 71(1):31-37.

Blair, A., H. Walker, K. Cantor, L. Burmeister, and K. Wiklund. 1985. Cancer among farmers. *Scand. J. Work Environ. Health* 11:397-407.

Bridges, B. A. and M. L. Mendelsohn. 1986. *Genetic Toxicology of Environmental Chemicals, Part B: Genetic Effects and Applied Mutagenesis.* Alan R. Liss, Inc., NY.

Brusick, D. J. 1987. *Principles of Genetic Toxicology*. 2nd ed. Plenum Press, NY.

Brusick, D. J., J. Ashby, F. de Serres, P. Lohman, T. Matsushima, B. Matter, M. Mendelsohn, and M. Waters. 1986.. Weight of evidence scheme for evaluation and interpretation of short-term results. In: *Genetic Toxicology of Environmental Chemicals, Part B: Genetic Effects and Applied Mutagenesis.* Alan R. Liss, Inc., NY.

Burks, S. L. 1982. Effects of oil on aquatic organisms. A review of selected literature. Prepared for the American Petroleum Institute, Washington, DC. 69 pp.

California Department of Health Services. 1980. Assessment of health risks from the proposed aerial application of malathion in Santa Clara County. The Hazard Evaluation System and Information Service and the Pesticide Unit, Epidemiology Studies Section, California Department of Health Services.

Cantor, K. 1982. Farming and mortality from non-Hodgkin's lymphoma: A case-control study. *Int. J. Cancer* 29:239-247.

Cantor, K. and A. Blair. 1984. Farming and mortality from multiple myeloma: a case-control study with the use of death certificates. *J. NCI* 72(2):251-255.

Cantor, K., G. Everett, A. Blair, R. Gibson, L. Schuman, and P. Isocson. 1985. Farming and non-Hodgkin's lymphoma. *Am. J. Epidemiol.* 122:535.

Carter, C. O. 1977. The relative contribution of mutant genes and chromosome abnormalities to genetic ill-health in man. *Progress in Genetic Toxicology* Vol. II. D. Scott, B. A. Bridges, and F. H. Sobels, (eds.) Elsevier/North Holland, Amsterdam.

Conaway, C. C., C. A. Schreiner, and S. T. Cragg. 1982. Mutagenicity evaluation of petroleum hydrocarbons. American Petroleum Institute, Publication 128-38. Report No. 30-31997.

Connell, D. W. and G. J. Miller. 1984. *Chemistry and Ecotoxicology of Pollution*. John Wiley and Sons, NY. 444 pp.

Courtemanch, D. L. and K. E. Gibbs. 1978. The effects of Sevin 4-Oil on lentic communities. In Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Maine 1976 and 1977. Maine Department of Conservation, Bureau of Forestry, Augusta. pp. 141-150.

Craigmill, A. L. 1981. Malathion. *Environmental Toxicology Newsletter*. Cooperative Extension, University of California, Davis, CA.

Cranmer, M. F. 1986. Carbaryl: a toxicological review and risk analysis. *Neurotoxicology* 7(1):247-332.

Denniston, C. 1982. Low level radiation and genetic risk estimation in man. *Annual Review of Genetics* 16:329-355.

Dobroski, C. J. 1985. Carbaryl: a profile of its behavior in the environment. Submitted to U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Contract No. 53-6395-1-151, submitted by Roy F. Weston, Inc., West Chester, PA.

Dobroski, C. J., Jr. and W. P. Lambert. 1984. Malathion: a profile of its behavior in the environment. Submitted to U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Contract No. 53-6395-1-151, submitted by Roy F. Weston, Inc., West Chester, PA.

Doull, J., C. D. Klassen, and M. O. Amdur. 1980. *Cassarett and Doull's Toxicology*. 2nd ed. MacMillan Publishing Co., NY.

Dunachie, J. F. and W. W. Fletcher. 1969. An investigation of the toxicity of insecticides to birds' eggs using the egg-injection technique. *Annals of Applied Biology* 64:409-423.

Ehling, U. H. 1988. Quantification of the genetic risk of environmental mutagens. *Risk Analysis* 8:45-57.

Eisenbrand, G., O. Ungerer, and R. Preussmann. 1975. The reaction of nitrate with pesticides. II. Formation. Chemical properties and carcinogenic activity of the N-nitroso derivative of N-methyl-n-napthyl carbamate (carbaryl). *Food and Cosmetics Toxicology* 13:365-367.

Eisenbrand, G., D. Schmahl, and R. Pruessman. 1976. Carcinogenicity in rats at high oral doses of N-nitrosocarbaryl, a nitrosated pesticide. *Cancer Letters* 281-284.

Elespuru, R. K. and W. Lijinsky. 1973. The formation of carcinogenic nitroso compounds from nitrite and some types of agricultural chemicals. *Food and Cosmetics Toxicology* 11(5):807-817.

Elespuru, R., W. Lijinsky, and J. Setlow. 1974. Nitrosocarbaryl as a potent mutagen of environmental significance. *Nature* 247:386-387.

Epstein, S. S., E. Arnold, J. Andrea, W. Bass, and Y. Bishop. 1972. Detection of chemical mutagens by the dominant lethal assay in the mouse. *Toxicology and Applied Pharmacology* 23:288-325.

Fischer, P. 1966. Effects of aircraft applications of malathion on fish and aquatic invertebrates. Parks and Wildlife Department, Austin, TX. Federal Aid Project No. F-17-R-1, Job No. 8.

Ghassemi, M., L. Fargo, Page Painter, Pam Painter, S. Quinlivan, R. Scofield, and A. Takata. 1981. Environmental fates and impacts of major forest use pesticides. Prepared for the U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. TRW Environmental Division, Redondo Beach, CA.

Gibbs, K. E., T. M. Mingo, and D. L. Courtemanch. 1984. Persistence of carbaryl (Sevin 4-oil) in woodland ponds and its effects on pond macroinvertebrates following forest spraying. *Canadian Entomologist* 116:203-213.

Gramlich, F. J. 1979. Effects of Sevin on songbird brain cholinesterase. In: Environment Monitoring of Cooperative Spruce Budworm Control Projects. Department of Conservation, Bureau of Forestry, Augusta, ME.

Grether, Judith K., John A. Harris, Raymond Neutra, and Kenneth W. Kizer. 1987. Exposure to aerial malathion application and the occurrence of congenital anomolies and low birth weight. *American Journal of Public Health* 77(8):1009-10.

Harry, J. B. 1977. A review of human exposure to Sevin, carbaryl insecticide with particular reference to the United States of America. Union Carbide Corporation, Agricultural Products Division, Salinas, CA.

Hayes, A. W. 1982a. *Principles and Methods of Toxicology*. Raven Press, NY.

Hayes, Wayland J. 1982b. *Pesticides Studied in Man.* Williams and Wilkins. Baltimore, MD.

Hoffman, D. J. and Albers. 1984. Evaluation of potential embryo toxicity and teratogenicity of 42 herbicides, insecticides, and petroleum contaminants to mallard eggs. *Arch. Environ. Contam. Toxicol.* 13:15-27.

Huddleston, E. W., C. R. Ward, and J. L. Pulley. 1968. Spring population trends of nontarget insects following the fourth year of the high plains boll weevil control program. *Entomological Reports* No. 68-2 (supplemental).

Hudson, R. H., R. K. Tucker, and M. A. Haegele. 1984. *Handbook of Toxicity of Pesticides to Wildlife.* 2nd ed. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Huff, J. E., R. Bates, S. L. Eustis, J. K. Haseman, and E. E. McConnell. 1985. Malathion and malaoxon: histopathology reexamination of the National Cancer Institute's carcinogenicity studies. *Environmental Research* 37:154-173.

Hulbert, P. J. 1978. Effects of Sevin, a spruce budworm insecticide on fish and invertebrates in the Mattawamkeas River in 1976. In: Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Maine 1976 and 1977. Maine Department of Conservation, Bureau of Forestry, Augusta, ME.

ICPEMC Committee 1 Final Report. 1983. Screening strategy for chemicals that are potential germ-cell mutagens in mammals. *Mutation Research* 114:117-177.

International Technical Information Institute (ITII). 1976. *Toxic and Hazardous Industrial Chemicals Safety Manual.* Tokyo, Japan.

International Agency for Research on Cancer. 1983. Malathion. In: IARC monographs, volume 30. World Health Organization. Lyon, France.

Johnson, W. W. and M. T. Finley. 1980. *Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates.* U.S. Department of the Interior, Fish and Wildlife Service. Resource Publication No. 137. Washington, DC.

Kalow, W. and A. Manton. 1961. Second-generation toxicity of malathion in rats. *Nature* 192:464-465.

Khera, K.S., C. Whalen, G. Trivett. 1978. Teratogenicity studies on linuron malathion, and methoxychlor in rats. *Toxicology and Applied Pharmacology* 45:435-444.

Klassan, C.D., M.O. Amdus, J. Doull, eds. 1986. *Cassarett and Doull's Toxicology.* 3rd ed. MacMillian Publishing Company, NY.

Krause, W. K., Hamam, J. Weissmuller. 1976. Damage to spermatogenesis in juvenile rats treated with DDVP and malathion. *Bulletin of Environmental Contamination and Toxicology* 15(4):458-462.

Kucera, Emil. 1987. Brain cholinesterase activity in birds after a city-wide application of malathion. *Bull. Environ. Contam. Toxicol.* 38:456-460.

Lagier, R. F. et al. 1974. Adjuvents decrease insecticide hazard to honey bees. Washington State University, College of Agriculture Research Center Bulletin No. 801. 7 pp.

Lake Ontario Environmental Laboratory (LOTEL). 1975. Environmental impact study of aerially applied Orthene on a forest and aquatic ecosystem. Lake Ontario Environmental Laboratory, State University College, Oswego, NY.

Lambert, W. P. 1985. Orthene: profile of its behavior in the environment. Submitted to the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Contract No. 53- 6395-1-151.

Larson, L. 1975. The selective toxicity of Orthene. University of California, Riverside dissertation.

Lijinsky, W. and D. Schmahl. 1978. Carcinogenicity of N-nitroso derivatives of N-methyl carbamate insecticides in rats. *Ecotoxicology and Environmental Safety* 2:413-419.

Lijinsky, W. and H. W. Taylor. 1976. The effect of substituents on the carcinogenicity of N-nitrosopyrrolidine in Sprague-Dawley rats. *Cancer Research* 36(6):1988-1990.

Lijinsky, W. and C. Winter. 1981. Skin tumors induced by painting nitrosoalkylureas on mouse skin. *Journal of Cancer Research and Clinical Oncology* 102:13-20.

Loomis, T. A. 1978. *Essentials of Toxicology*. Lea and Febiger, Philadelphia, PA.

Marancik, J. 1976. Effect of insecticides used for spruce budworm control in 1975 on fish. In 1975 cooperative pilot control project of Dylax, Matacil, and Sumithon for spruce budworm control in Maine, pp. 11- 34. U.S. Department of Agriculture, Forest Service Northeast Area, State and Private Forest Insect District Management, Upper Darby, PA, August 1976.

Matsunaga, E. 1982. Perspectives in mutation epidemiology: incidence and prevalence of genetic diseases (excluding chromosomal aberrations) in human populations. *Mutation Research* 99:95-128.

Maxwell, R. C. 1982. Meaning of label signal words. *Pesticide Report* 43:4-5. Washington State University, Cooperative Extension Service, Pullman, Washington. (As cited in Walstad and Dost, 1984.)

McCullough, R. D. and J. G. Stanley. 1980. Effects of carbaryl (Sevin) on brook trout in streams receiving drift from spraying of nearby forests. Maine Cooperation of Fisheries Research Unit, University of Maine, Orono, ME.

McEwen, L. C. and L. R. DeWeese. 1981. Summary of 1981 field studies of acephate effects on rangeland wildlife. U.S. Fish and Wildlife Service, Fort Collins, Colorado. (Animal and Plant Health Inspection Service—Final Environmental Impact Statement.) Unpublished.

McKusick, V. A. 1983. *Mendelian Inheritance in Man*. 6th ed. Johns Hopkins University Press, Baltimore, MD.

Mecler, F. J. and R. P. Beliles. 1979. Teratology study in rats. Diesel fuel final report. American Petroleum Institute Medical Research Publication No. 27-32174.

Melzian, B. D. 1983. Acute toxicity, histopathy, and bioconcentration. Retention studies with No. 2 fuel oil and the blue crab, *Callinectes sapidus* Rathbun. *Dissertation Abstracts International B: The Sciences and Engineering* 43(1).

Moeller, H. G. and J. A. Rider. 1962. Plasma and red blood cell cholinesterase acitivity as indicators of the threshold of incipient toxicity of ethyl-p-nitrophenyl thionobenzene phosphonate (EPN) and malathion in human beings. *Toxicology and Applied Pharmacology* 4:123-130.

Moffett, J.O., H.L. Morton, and R.L. MacDonald. 1972. Toxicity of some herbicidal sprays to honeybees. *Journal of Economic Entomology* 65(1):32-36.

Mommsen, S. and J. Aagard. 1984. Occupational exposures as risk indicator of male bladder carcinoma in a predominantly rural area. *Acta. Radiol.* 23(2-3):147- 52.

Moulding, J. D. 1972. The impact on forest bird and nontarget arthropod populations of the use of the insecticide Sevin for gypsy moth control. Rutgers University Ph.D. thesis. Unpublished.

Mulla, M. S. and L. S. Mian. 1981. Biological and environmental impacts of the insecticides malathion and parathion on nontarget biota in aquatic ecosystems. *Residue Reviews* 78:101-135.

Murphy, S. D. 1980. Pesticides. In: *Cassarett and Doull's Toxicology* (J. Doull, C. Klassen, and M. Amdur, eds.). MacMillan Publishing Company, NY.

Murray, F. J., R. F. Staples, and B. A. Schwetz. 1979. Teratogenic potential of carbaryl given to rabbits and mice by gavage or by dietary inclusion. *Toxicology and Applied Pharmacology* 51:81-89.

National Cancer Institute (NCI). 1978. Bioassay of malathion for possible carcinogenicity. DHEW Publication No. (NIH) 78-824.

National Cancer Institute (NCI). 1979a. Bioassay of malathion for possible carcinogenicity. NIH Publication No. 79-1748.

National Cancer Institute (NCI). 1979b. Bioassay of malaoxon for possible carcinogenicity. NIH Publication No. 79-1390.

National Institute for Occupational Safety and Health (NIOSH). 1987. Registry of Toxic Effects of Chemical Substances. U.S. Department of Health and Human Services. Washington, DC.

National Library of Medicine (NLM). 1986. Hazardous Substances Data Bank. Bethesda, MD.

National Library of Medicine (NLM). 1987. Hazardous Substances Data Bank. Files on methamidophos and kerosene. Bethesda, MD.

National Library of Medicine (NLM). 1988. Hazardous Substances Data Bank. Malathion file. Bethesda, MD.

National Research Council (NRC). 1977. *Drinking Water and Health.* National Academy Press, Washington, DC.

National Research Council (NRC). 1986. *Drinking Water and Health, Volume 6.* R.D. Thomas, ed. National Academy Press, Washington, DC.

Pet-Edwards, J., V. Chankong, H. S. Rosenkranz, and Y. Y. Haines. 1985. Application of the carcinogenicity prediction and battery selection (CPBS) method to the Gene-Tox data base. *Mutation Research* 153:187-200.

Pfadt, R. E., N. L. Marston, and F. A. Lawson. 1985. Effect of ULV malathion grasshopper spray on nontarget arthropods. *Science Monograph* 48. Agricultural Experiment Station, University of Wyoming, Laramie, WY.

Rabeni, C. F. 1978. The impact of Orthene, a spruce budworm control project, Maine 1976 and 1977. Maine Department of Conservation, Bureau of Forestry, Augusta, ME.

Rabeni, C. F. and K. E. Gibbs. 1979. The impact of Orthene, a spruce budworm insecticide, on aquatic macroinvertebrates in Maine, 1977. U.S. Department of Agriculture, Forest Service. Rep. NA-FR-7.

Rao, G. S., K. Kannan, S. K. Goel, K. P. Pandya, and R. Shanker. 1984. Subcutaneous kerosene toxicity in albino rats. *Environ. Res.* 35(2):516-530.

Rickard, R. W., G. Walter-Echols, H. W. Dorough, and L. J. Lawrence. 1982. Importance of pH in assessing the potential for nitrosocarbamate formation in the stomach. *Pesticide Biochemistry and Physiology* 18(3):325-333. (As cited in Cranmer, 1986.)

Russell, L. B., C. S. Aaron, F. de Serres, W. M. Generoso, K. L. Kannan, M. Shelby, J. Springer, and P. Voytek. 1984. Evaluation of existing mutagenicity bioassays for purposes of genetic risk assessment. *Mutation Research* 134:143-157.

Sassaman, J. F. 1987. Pesticide Background Statements: *Bacillus thuringiensis.* U.S. Department of Agriculture, Forest Service, Forest Pest Management.

Scharf, S. M., D. Heimer, and J. Goldstein. 1981. Pathologic and physiologic effects of aspiration of hydrocarbons in the rat. *Am. Rev. Respir. Div.* 124(5):625-629.

Schoettger, R. A. and W. L. Mauck. 1976. Toxicity of experimental forest insecticides to fish and aquatic invertebrates. Fish—Pesticide Research Laboratory, U.S. Fish and Wildlife Service, Columbia, MO.

Shelby, M. D. 1988. The genetic toxicity of human carcinogens and its implications. *Mutation Research* 204:3-15.

Sinclair, R. L. 1968. Effects of quail, migratory birds, and nongame birds on aerial applications of malathion and other insecticides. Job Completion Report, Federal Aid in Wildlife Act, Texas, Federal Aid Project No. W-88-R-7.

Smalley, H. E., J. M. Gurtis, and F. L. Earl. 1968. Teratogenic action of carbaryl in beagle dogs. *Toxicology and Applied Pharmacology* 13:392-403.

Smith, Gregory J. 1987. Pesticide Use and Toxicology in Relation to Wildlife: Organophosphorus and Carbamate Compounds. U.S. Department of the Interior, Fish and Wildlife Service. Washington, DC.

Sprague, J. B. 1985. Factors that modify toxicity. In *Fundamentals of Aquatic Toxicology*. Rand, G. M. and S. R. Petrocelli (eds.). Hemisphere Publishing Corporation, NY.

Starek, A. and M. Kaminski. 1981. Comparative studies on toxicity of various dielectrics, petroleum derivatives, used in electroerosion technology. IV. Morphological and cytoenzymatic changes in the lungs and acid-base imbalance in rats chronically exposed to petroleum hydrocarbons. *Med. Pr.* 32(2):69-81.

Starek, A. and M. Kaminski. 1982. Comparative studies on the toxicity of various dielectrics—petroleum derivitives used in the electroerosion technic. V. Functional, morphological, and cytoenzymatic charges in the kidneys of rats chronically exposed to petroleum hydrocarbons. *Med. Pr.* 32(2):69-81.

Szaro, R. C., P. H. Alblers, and N. C. Coon. 1978. Petroleum: effects on mallard egg hatchability. *Journal of Wildlife Management* 42:404-406.

Trial, J. G. 1978. The effects of Sevin 4-Oil on aquatic insect communities of streams: a continuation of 1976 studies. In: Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Maine 1976 and 1977. Maine Department of Conservation, Bureau of Forestry, Augusta, ME. pp. 124-140.

Trial, J. G. 1979. The effects of Sevin 4-Oil on aquatic insect communities of streams (1976-1978). In: Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Maine 1978. Maine Department of Conservation, Bureau of Forestry, Augusta, ME. pp. 6-22.

U.S. Department of Agriculture (USDA). 1985. Gypsy moth suppression and eradication projects: final environmental impact statement. Washington, DC.

U.S. Department of Health, Education, and Welfare (DHEW). 1976. Criteria for recommended standards ... occupational exposure to malathion. Public Health Service, National Institute for Occupational Safety and Health. Report No. NIOSH-76-205.

U.S. Department of Energy (DOE) 1983. Final environmental impact statement: transmission facilities vegetation management program. Bonneville Power Administration. Washington, DC, Government Printing Office. [DOE/EIS-0097-F]

U.S. Department of Health and Human Services (DHHS). 1985. Fourth annual report on carcinogens. Summary 1985. Public Health Service. NTP 85-002.

U.S. Department of the Interior (DOI). 1963. Pesticide wildlife studies—a review of fish and wildlife service investigations during the calendar year. U.S. Department of the Interior Circular 199.

U.S. Department of the Interior (DOI). 1967. Special report, pesticide surveillance program, November 10, 1966. Bureau of Sport Fisheries and Wildlife. Oakland, CA.

U.S. Environmental Protection Agency (EPA). Undated. Carbaryl Position Document No. 1. Office of Special Pesticide Reviews, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1975. Initial scientific and minieconomic review of malathion. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1982a. Toxicology chapter of the methamidophos registration standard. March 1982.

U.S. Environmental Protection Agency (EPA). 1982b. Guidance for the reregistration of manufacturing use and certain end use products containing methamidophos. September 1982.

U.S. Environmental Protection Agency (EPA). 1984a. Tox one-liner for acephate. No. 2A. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1984b. Tox one-liner for carbaryl. Tox. Chem. No. 160. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1984c. Guidance for the registration of pesticide products containing carbaryl as the active ingredient. Office of Pesticide Programs, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1984d. Addendum to science chapters prepared for the acephate reregistration standard. Ecological Effects Branch, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1985. Guidance for the reregistration of pesticide products containing acephate. Case #42. Washington, DC, September 1985.

U.S. Environmental Protection Agency (EPA). 1986a. Guidelines for Mutagenicity Risk Assessment. *Federal Register* 51(185):34006-34012, September 24, 1986.

U.S. Environmental Protection Agency (EPA). 1986b. Guidelines for Carcinogen Risk Assessment. *Federal Register* 51(185):33992-34003. September 24, 1986.

U.S. Environmental Protection Agency (EPA). 1986c. Health effects assessment for benzo(a)pyrene. Environmental Criteria and Assessment Office, Cincinnati, OH. NTIS PB No. 86 134335/AS.

U.S. Environmental Protection Agency (EPA) 1986d. Health effects assessment for benzene. Environmental Criteria and Assessment Office, Cincinnati, OH. NTIS PB No. 86 134483/AS.

U.S. Environmental Protection Agency (EPA). 1987a. Tox one-liner: malathion. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1987b. Guidance for the reregistration of pesticide products containing acephate as the active ingredient. Office of Pesticides and Toxic Substances, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1988a. Tox one-liner for malathion. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1988b. Integrated risk information system. Office of Research and Development. Cincinnati, OH.

U.S. Environmental Protection Agency (EPA). 1988c. Reference dose (RFD) tracking report. November 15, 1988. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1988d. Guidance for the reregistration of pesticide products containing malathion as the active ingredient. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1988e. Health advisories for 50 pesticides. Office of Drinking Water. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1988f. Tox one-liner for carbaryl. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Fish and Wildlife Service (FWS). 1986. Letter and attachments to APHIS concerning effect of Mormon cricket control on endangered wildlife species in Utah and Colorado. Galen L. Buterbaugh, Regional Director, Denver, CO.

U.S. Food and Drug Administration (FDA). 1980. Methamidophos insecticide. Bureau of Foods. Washington, DC.

Weil, C. A., M. D. Woodside, C. P. Carpenter, and H. P. Smyth, Jr. 1972. Current status of tests of carbaryl for reproductive and teratogenic effect. *Toxicology and Applied Pharmacology* 14:409-419.

Weil, C. S., M. D. Woodside, B. Bernard, N. L. Conara, and C. P. Carpenter. 1973. Comparative effect of carbaryl on rat reproduction and guinea pig teratology when fed either in the diet or by stomach intubation. *Toxicology and Applied Pharmacology* 26:621-638.

Weininger, R. B., G. Davis, and C. D. Hawks. 1987. Herbicides and cancer. *JAMA* 257(17):2292.

Wester, R. C., H. Maibach, D. A. W. Bucks, and R. H. Guy. 1983. Malathion percutaneous absorption after repeated administration to man. *Toxicology and Applied Pharmacology* 68:116-119.

Wills, J. H., E. Janeson, and F. Coulston. 1968. The effects of oral doses of carbaryl on man. *Clinical Toxicology I* (3):265-271.

Wolfsdorf, J. and D. Paed. 1976. Kerosine intoxication: an experimental approach to the etiology of the CNS manifistation in primates. *J. Pediatr.* 88(6):1037-1040.

Zucker, E. 1985. Standard evaluation procedure—acute toxicity test for freshwater fish. Prepared for U.S. Environmental Protection Agency. Washington, DC.

Section F3

American Cyanamid. 1986. Technical information—Cythian®. Agricultural Division. Wayne, NJ.

Atallah, Y. H., W. P. Cahill, and D. M. Whitacre. 1982. Exposure of pesticide applicators and support personnel to 0-ethyl 0-(4-nitrophenyl) phenylphosphonothioate (EPN). *Archives of Environmental Contamination and Toxicology* 11:219-225.

Arms, A. D. 1988. Oak Ridge National Laboratory, personal communication.

Arnold, J. G. and J. R. Williams. 1987. Validation of SWRRB-simulator for water resources in rural basins. *Journal of Water Resource Planning and Management* 113(2):243-256.

Carsel, R. F. 1980. *Pesticide Runoff Simulator (Users Manual).* Prepared for Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency, Contract No. 68-01-3840.

Carsel, R. F., C. N. Smith, L. A. Mulkey, J. D. Dean, and P. P. Jowise. 1984. Users manual for the pesticide root zone model (PRZW) release 1. U. S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA. EPA/600/3-84/109.

Curley, W. H. and J. M. Donohue. 1986. Risk analysis of multiple pesticide applications for the rangeland cooperative management program. USDA Animal and Plant Health Inspection Service, Washington, DC.

Dennee, J. 1988. Personal communication with Supervisor of Water Supply and Treatment Division of Utilities Department for The Dalles, OR.

Feldmann, R. J. and H. I. Maibach. 1974. Percutaneous penetration of some pesticides and herbicides in man. *Toxicology and Applied Pharmacology* 28:126-132.

Golovin, M. N. and A. A. Putnam. 1962. Intertial impaction on single elements. *I and E.C. Fundamentals* 1(4):264-273.

Gordon, M. S., G. A. Bartholomew, A. D. Grinnell, C. B. Jorgensen, and F. N. White. 1968. *Animal function: principles and adaptations.* MacMillan Company, NY.

Harvey, G. T. 1985. The taxonomy of the coniferophagus *Choristoneura* (Lepidoptera Tortricidae): a review. In: *Recent Advances in Spruce Budworms Research.* Canadian Forestry Service, Ottowa, Ontario.

Helliwell, R. 1988. Memorandum to U. S. Forest Service containing list of food plants on Indian reservations and in National Forests.

Hoerger, F. and E. E. Kenaga. 1972. Pesticide residues on plants: correlation of representative data as a basis for estimation of their magnitude in the environment. In: *EQS: environmental quality and safety. Vol I. Global aspects of toxicology and technology as applied to the environment.* F. Coulston (ed.). Academic Press, NY.

Honeycutt, R. C. and L. G. Ballantine. 1983. Mathematical modeling application to environmental risk assessments. In: *Fate of Chemicals in the Environment.* A.C.S. Symposium Series, American Chemical Society, Washington, DC, Volume 255, pp. 249-262.

Hutchinson, V. H., W. G. Whitford, and M. Kohl. 1968. Relation of body size to gas exchange in anurans. *Physiological Zoology* 41:65-85.

Kendeigh, S. C. 1970. Energy requirements for existence in relation to size of bird. *The Condor* 72:60-65.

Knisel, W. G. (ed.). 1980. *CREAMS: A Field-Scale Model for Chemicals, Runoff and Erosion from Agricultural Management Systems,* U.S. Department of Agriculture, Conservation Research Report No. 26, 640 pp.

Lasiewski, R. C. and W. A. Calder, Jr. 1971. A preliminary allometric analysis of respiratory variables in resting birds. *Respiration Physiology* 11:152-166.

Lavy, T. L., J. S. Shepard, and J. D. Mattice. 1980. Exposure measurements of applicators spraying (2,4,5-trichlosophenosy) acetic acid in the forest. *J. Agric. Food Chem.* 28:626-630.

Leonard, R. A., W. G. Knisel, and D. A. Shill. 1987. GLEAMS: groundwater loading effects of agricultural management systems. *Transactions of the ASAE* 30(5):1403-1418.

Lowrey, M. 1988. Personal communication with Forest Service hydrologist.

MacLean, D. A. 1985. Effects of spruce budworm outbreaks on forest growth and yield. *Recent Advances in Spruce Budworms Research.* Canadian Forestry Service, Ottawa, Ontario.

Moore, J. A. (ed.) 1964. *Physiology of the Amphibia.* Academic Press, NY.

Newton, M. and L. A. Norris. 1981. Potential exposure of humans to 2,4,5-t and TCDD in the Oregon coast ranges. *Fundamental and Applied Toxicology* 1:339-346.

Parcell, J. 1988. Personal communication with Forest Service soil scientist.

Popendorf, W. J. 1985. Advances in the unified field model for reentry hazards. In: *Dermal Exposure Related to Pesticide Use: Discussion of Risk Assessment.* B. C. Honeycutt, G. Zweig, and N. N. Ragsdale (eds.). Washington, DC. ACS Symposium Series 273.

Popendorf, W. J. and J. T. Leffingwell. 1982. Regulating OP pesticide residues for farm worker protection. *Residue Rev.* 82:125-201.

Reinert, J. C. and D. J. Severn. 1985. Dermal exposure to pesticides: the Environmental Protection Agency's viewpoint. In: *Dermal Exposure Related to Pesticide Use: Discussion of Risk Assessment.* ACS Symposium Series, Washington, DC.

Rose, A. 1988. Personal communication with manufacturer of acephate.

Schmidt-Neilsen, K. 1972. *How Animals Work.* Cambridge University Press.

Toll, L. 1988. Personal communication with Water Master of The Dalles, OR.

Travis, C. C. and A. D. Arms. 1988. Bioconcentration of organics in beef, milk, and vegetation. *Environmental Science and Technology* 22(3):271-274.

U.S. Bureau of Land Mangement (BLM). 1987. Final environmental impact statement: Northwest area noxious weed control program. U. S. Department of Interior, Washington, DC.

U.S. Department of Agriculture, Forest Service. 1979. *Soil Resource Inventory.* Mt. Hood National Forest, Pacific Northwest Region, 312 pp.

U.S. Department of Agriculture, Soil Conservation Service. 1972. *SCS National Engineering Handbook-Section 4 Hydrology.*

U.S. Department of Agriculture, Forest Service. 1980. *An Approach to Water Resources Evaluation of Non-point Silivicultural Sources (A Procedural Handbook).* Prepared for Environmental Research Lab, Athens, GA.

U.S. Department of Agriculture (USDA). 1984. *Pesticide Background Statements, Volume I: Herbicides.* Agricultural Handbook No. 633, Washington, DC.

U.S. Department of Agriculture (USDA). 1985a. Managing trees and stands susceptible to Western spruce budworm. U. S. Forest Service Technical Bulletin No. 1695, Washington, DC.

U.S. Department of Agriculture (USDA). 1985b. *Predators of the spruce budworm.* U. S. Forest Service Agriculture Handbook No. 644, Washington, DC.

U.S. Department of Agriculture (USDA). 1987a. Western spruce budworm management in Oregon and Washington during 1987. Environmental assessment for U.S. Forest Service, Washington, DC.

U.S. Department of Agriculture (USDA). 1987b. Western spruce budworm. U.S. Forest Service Technical Bulletin No. 1694, Washington, DC.

U.S. Drug Enforcement Agency (DEA). 1985. Final environmental impact statement on the eradication of cannabis on Federal lands in the continental United States. U.S. Department of Justice, Washington, DC.

U.S. Drug Enforcement Agency (DEA). 1986. Supplement to the draft environmental impact statement: cannabis eradication on nonfederal and Indian lands in the contiguous United States and Hawaii. U.S. Department of Justice, Washington, DC.

U.S. Environmental Protection Agency, Office of Pesticide Programs, (EPA). 1986. Hazard evaluation division standard evaluation procedure, ecological risk assessment. EPA-540/9-85-001. Washington, DC.

Verschuerne, K. 1983. *Handbook of Environmental Data on Organic Chemicals.* Van Nostrand Reinhold Company, NY.

Weber, J. B., P. J. Shea, and H. J. Strek. 1980. An evaluation of nonpoint sources of pesticide pollution in runoff. In: *Environmental Impact of Nonpoint Source Pollution.* M. R. Overcash and J. M. Davidson (eds.) Ann Arbor Science Pub. Inc., pp. 69-98.

Williams, J. R., A. D. Nicks, and J. G. Arnold. 1985. Simulator for water resources in rural basins. *Journal of Hydraulic Engineering* 3(6):970-986.

Yates, W. E., N. B. Akesson, and R. E. Cowden. 1978. Atmospheric transport of sprays from helicopter applications in mountainous terrain. ASAE paper no. 78-1504.

Yates, W. E., N. B. Akesson, and R. E. Cowden. 1984. Measurement of drop size frequency from nozzles used for aerial applications of pesticides in forests. USDA Forest Service, Washington, DC.

Section F4

Calabrese, E. J. 1978. *Pollutants and High Risk Groups.* John Wiley and Sons, NY.

Calabrese, E. J. 1984. *Ecogenetics.* John Wiley and Sons, NY.

Calabrese, E. J. 1985. Uncertainty factors and interindividual variation. *Regulatory Toxicol. Pharmacol.* 5:2190-196.

Calabrese, E. J. and M. W. Dorsey. 1984. *Healthy Living in an Unhealthy World.* Simon and Schuster, NY.

California Department of Health Services. 1980. Assessment of health risks from the proposed aerial application of malathion in Santa Clara County. Epidemiology Studies Section. Berkeley, CA.

Davies, J. E., V. H. Freed, H. F. Enos, R. C. Duncan, A. Barquet, C. Morgade, L. Peters, and J. Danauskas. 1982. Reduction of pesticide exposure with protective clothing for applicators and mixers. *Journal of Occupational Medicine* 24(6):464-468.

Doull, J., C. D. Klassen, and M. O. Amdus. 1980. *Cassarett and Doull's Toxicology.* 2nd ed. MacMillian, NY.

Kociba, R. J., and W. R. Mullison. 1985. Toxicological interactions with ag chemicals. *Farm Supplier.* August.

Lijinsky, W. and H. W. Taylor. 1976. The effect of substituents on the carcinogenicity of N-nitrosopyrrolidine in Sprague-Dawley rats. *Cancer Research* 36(6):1988-1990.

Marzulli, F. N. and H. I. Maibach. 1983. *Dermatotoxicology.* 2nd ed.. Hemisphere Publishing Company, Washington, DC. 693 pp.

National Academy of Sciences. 1977. *Drinking Water and Health.* Safe Drinking Water Committee, Advisory Center on Toxicology, Assembly of Life Sciences, National Research Council, National Academy of Sciences, Washington, DC. 939 pp.

Sassaman, J. F. 1987. Pesticide background statements: *Bacillus thuringiensis.* U. S. Department of Agriculture Forest Service, Forest Pest Management.

U.S. Department of Agriculture (USDA). 1985. Final environmental impact statement as supplemented: gypsy moth suppression and eradication projects. Animal and Plant Health Inspection Service, Washington, DC.

U.S. Department of Agriculture (USDA). 1988. Letter from A. J. West to Regional Foresters, Station Directors, and Area Directors regarding biological pesticide Dioburden.

U.S. Environmental Protection Agency (EPA). 1986a. Guidelines for the health risk assessment of chemical mixtures. *Federal Register* 52(185):34014-340251, September 24, 1986.

U.S. Environmental Protection Agency (EPA). 1986b. June 9 letter to Guy Baier on the toxicity of BLM proposed formulations. Office of Pesticide Programs, Washington, DC.

U.S. Environmental Protection Agency (EPA). 1986c. Standard evaluation procedure: ecological risk assessment. Office of Pesticide Programs, Washington, DC.

Volk, W. A. and M. F. Wheeler. 1983. *Basic Microbiology.* 4th ed. J. B. Lippincott Company, Toronto, Ontario.

Appendix F-A

Aly, O. M. and M. A. El-Dib. 1971. Studies on the persistence of some carbamate insecticides in the aquatic environment. I. Hydrolysis of Sevin, Baygon, Pyrolan, and Dimetilan in waters. *Water Research* 5:1191-1205.

Anderson, J. W. 1975. Laboratory studies on the effects of oil on marine organisms: an overview. API Publication No. 4249. American Petroleum Institute, Washington, DC.

Bender, M. E. 1969. Uptake and retention of malathion by the carp. *Progressive Fish Culturist* 31(3):155-159.

Bingham, F., R. P. Tosset, and D. Warshawsky. 1979. Carcinogenic potential of petroleum hydrocarbons. *J. Environ. Pathology and Toxicology* 3:483-563.

Buikema, A. L., Jr., and A. C. Hendrick. 1980. A review. Prepared for the American Petroleum Institute. Report No. 27-33296.

Butt, J.A. (ed.) 1986. *Characterization of Spilled Oil Samples: Purpose, Sampling, Analysis, and Interpretation.* The Institute of Petroleum, John Wiley and Sons, NY.

California Department of Fish and Game. 1963. An investigation into the effect on fish of Sevin (carbaryl) used in rice culture. PR Project W-52-R, Wildlife Investigation Laboratory, Resource Agency, California Department of Fish and Game. Unpublished.

Chevron Chemical Company. 1973. Orthene insecticide-environmental impact report. Chevron Chemical Co., Richmond, CA.

Clement Associates. 1978. Relative risks of Dimilin and alternative pesticides. Clement Associates, Washington, DC.

Curley, W. H. and J. M. Donohue. 1986. Risk analysis of multiple pesticide applications for the rangeland cooperative management program. Prepared for U. S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Prepared by V. J. Ciccone and Associates, VA.

Davis, J. B., V. E. Farmer, R. E. Kreider, A. E. Staub, and K. M. Reese. 1972. The migration of petroleum in soil and groundwater: principles and countermeasures. American Petroleum Institute Committee on Environmental Affairs. Pub. No. 449. Washington, DC. 36 pp.

Dobroski, C. J., Jr. 1985. Carbaryl: A profile of its behavior in the environment. Submitted to U. S. Department of Agriculture, Animal and Plant Health Inspection Service, by Roy F. Weston, Inc., West Chester, PA.

Dobroski, C. J., Jr. and W. P. Lambert. 1984. Malathion: A profile of its behavior in the environment. Submitted to U.S. Department of Agriculture. Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Contract No. 53-6395-1-151, submitted by Roy F. Weston, Inc., West Chester, PA.

Dolinger, P. M. and W. L. Fitch. 1979. Carbaryl: Monograph number one, environmental health evaluations of California restricted insecticides. Prepared for the Environmental Assessment Team of the California Department of Food and Agriculture by Peter M. Dolinger Associates, Menlo Park, CA.

Dutcher, J. D. and D. C. Sheppard. 1981. Predation of pecan weevil larvae by red imported fire ants. *Journal of the Georgia Entomological Society* 16(2):203-211.

Eichelberger, J. W. and J. J. Lichtenberg. 1971. Persistence of pesticides in river water. *Environmental Science and Technology* 5(6):541-544.

Felley, D.R. 1970. The effect of Sevin (1-naphthyl N-methyl carbamate) as a watershed pollutant. Ph.D. Dissertation, State of University of New York, College of Forestry, Syracuse University. Syracuse, NY. Unpublished.

Focht, D. D. and H. Joseph. 1974. Microbial activity in soils treated with acephate and monitor. *Journal of Environmental Quality* 3(4):327-328.

Ghassemi, M., L. Fargo, P. Painter, S. Quinlivan, R. Scofield, and A. Takata. 1981. *Environmental Fates and Impacts of Major Forest Use Pesticides.* Prepared for U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. TRW Environmental Division, Redondo Beach, CA.

Gibson, W. P. and R. G. Burns. 1977. The breakdown of malathion in soil and soil components. *Microbial Ecology* 3(3):219-230.

Giles, R. H., Jr. 1970. The ecology of a small forested watershed treated with the insecticide malathion—S^{25}. *Wildlife Monographs*, No. 24.

Gruse, W. A. and D. R. Stevens. 1960. *Chemical Technology of Petroleum.* 3rd ed. McGraw-Hill, NY. 675 pp.

Heywood, D. L. 1975. Degradation of carbamate insecticides in soil. *Environmental Quality and Safety* 4:128-133.

Horne, R.A. 1978. *The Chemistry of Our Environment.* John Wiley and Sons, Inc., NY.

Hussain, M. A. and P. C. Oloffs. 1980. Orthene (insecticide) residues in a creek. Proceedings of the 15th Annual Workshop for Pesticide Residue Analysts. Regina, Canada, April 30-May 2, 1980, pp. 12-23. Canadian Plains Research Center, University of Regina, Canada.

International Technical Information Institute (ITII). 1976. *Toxic and Hazardous Industrial Chemicals Safety Manual.* Tokyo, Japan

Johnson, D. P. and H. A. Stansbury. 1965. Adaptation of Sevin insecticide (carbaryl) residue method to various crops. *Journal of Agricultural and Food Chemistry* 13:235-238.

Ladd, J. N. 1956. The oxidation of hydrocarbons by soil bacteria: I. Morphological and biochemical properties of a soil Diptheroid utilizing hydrocarbons. *Australian Journal of Biological Sciences* 9:92.

LaFleur, K. 1976. Movement of carbaryl through Congaree soil into groundwater. *Journal of Environmental Quality* 5:91-92.

Lambert, W. P. 1985. Orthene: profile of its behavior in the environment. Submitted to U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Contract No. 53-6395-1-151. Washington, DC.

Lamberton, J. G. and R. R. Claeys. 1970. Degradation of 1-naphthol in sea water. *Journal of Agricultural and Food Chemistry* 18(1):92-96.

Law Engineering Testing Company. 1982. Review of ground-water models. Prepared for the American Petroleum Institute. Washington, DC. 69 pp.

Lichenstein, E. P., K. R. Schulz, R. F. Skrentny, and Y. Tsukano. 1966. Toxicity and fate of insecticide residues in water. *Archives of Environmental Health* 12:199-212.

Liu, S. Y. and J. M. Bollag. 1971. Carbaryl decomposition to 1-napthyl Ccrbamate by *Aspergillus terreus*. *Pesticide Biochemistry and Physiology* 1:366-372.

Lyman, W. J., W. F. Reehl, and D. H. Rosenblatt (eds.) 1981. Research and development of methods for estimating physico-chemical properties of organic compounds of environmental concern. Report No. C-82426 by Arthur D. Little, Inc., under contract DAMD-17-78-C-0873, U.S. Army Medical R&D Command, Ft. Detrick.

Mabey, W. R., J. H. Smith, R. T. Podoll, H. L. Johnson, T. Mill, T. W. Chou, J. Gates, I. Waight Partridge, H. Jaber, and D. Vanderberg. 1982. Aquatic fate process data for organic priority pollutants: final report. Prepared by SRI International for the U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC. EPA Contract No. 68-01-3867/68-03-2981.

Mann, G. S. and S. L. Chopra. 1969. Residues of carbaryl on crops. *Pesticides Monitoring Journal* 2:163-165.

Matsumura, F. and G. M. Baush. 1966. Malathion degradation by *Trichoderma viride* and a *Pseudomonas* species. *Science* 153(3741):1278-1280.

Morrison, R. T. and R. N. Boyd. 1974. *Organic Chemistry*. 34 ed. Allyn and Bacon, Inc., Boston.

Moulding, J. D. 1972. The impact on forest bird and nontarget arthropod populations of the use of the insecticide Sevin for gypsy moth control. Rutgers University Ph.D. Thesis. Unpublished.

National Library of Medicine (NLM). 1987. Hazardous substances databank. Bethesda, MD.

Newmann, H.J., B. Paczynska-Lahme, and D. Severin. 1981. Composition and properties of petroleum. *Geology of Petroleum*. Vol. 5. H. Beckman, ed. Halsted Press, New York.

Nigg, H. N., J. A. Reinert, J. H. Stamper, and G. E. Fitzpatrick. 1981. Disappearance of acephate, methamidophos, and malathion from citrus foliage. *Bulletin of Environmental Contamination and Toxicology* 26(2):267-272.

Pascal, D.C. and M. E. Neville. 1976. Chemical and microbial degradation of malaoxon in an Illinois soil. *Journal of Environmental Quality* 5(4):441-443.

Romine, R. R. and R. A. Bussian. 1971. The degradation of carbaryl after surface application to a farm pond. Union Carbide Project Report 111A13. Unpublished.

Routh, J. I., D. P. Eyman and D. J. Burton. 1971. *A Brief Introduction to General, Organic, and Biochemistry*. W.B. Sanders Co., Philadelphia, PA. 459 pp.

Saini, M. I. and W. H. Dobough. 1970. Persistence of malathion and methyl parathion when applied as ultra-low-volume and emulsifiable concentration sprays. *Journal of Economic Entomology* 63:405-408.

Sassaman, J.F. 1987. Pesticide background statement: *Bacillus thuringiensis*. Preprared for USDA Forest Service by the MITRE Corporation, McLean, VA.

Spacie, A. and J. L. Hamelink. 1985. Bioaccumulation. In: *Fundamentals of Aquatic Toxiology*. G. M. Rand and S. R. Petrocelli (eds.). Hemisphere Publishing Corporation, NY. pp. 495-525.

Speight, J. E. 1980. *The Chemistry and Technology of Petroleum*. Marcel and Depper, Inc., NY.

Szeto, S. Y., H. R. McCarthy, P. C. Oleffs, and R. F. Shepherd. 1979. The fate of acephate and carbaryl in water. *Journal of Environmental Science and Health* 14(6):635-654.

Thomson, W. T. 1979. *Agricultural Chemicals, Book I: Insecticides, Acaricides, and Ovicides*. 1979-80 Rev. Thomson Publications. Fresno, CA.

Toia, R. F., R. B. March, N. Umetsu, N. M. Mallipudi, R. Allahyari, and T. R. Fukuto. 1980. Identification and toxicological evaluation of impurities in technical malathion and fenthion. *Journal of Agricultural and Food Chemistry* 28(3):599-604.

Union Carbide. 1982. Sevin 50-W label information. Institute, West Virginia.

U.S. Department of Agriculture (USDA) 1976. Northern region: pilot project to evaluate Dylox and Orthene for controlling the western spruce budworm—environmental anaylsis report. Helena National Forest. March 1976.

U.S. Department of Energy. 1983. Bonneville Power Administration. *Final environmental impact statement: tranmission facilities vegetation management program.* DOE/EIS-0097-F. U. S. Department of Energy, U.S. Government Printing Office, Washington, DC. 464 pp.

U.S. Environmental Protection Agency (EPA). 1981. Methamidophos—Task 3: Environmental Fate Profile. Submitted to EPA by Enviro Control, Inc.

U.S. Environmental Protection Agency (EPA). 1984. Guidance for the reregistration of pesticide products containing carbaryl as the active ingredient. Office of Pesticide Programs. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1985. Guidance for the reregistration of pesticide products containing acephate as the active ingredient. Office of Pesticide Programs. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1987. Guidance for the reregistration of pesticide products containing acephate as the active ingredient. Office of Pesticides and Toxic Substances. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1988. *Pesticide Fact Handbook.* Noyes Data Corporation. Park Ridge, NJ.

U.S. Food and Drug Administration (FDA). 1980. Methamidophos—insecticide, SI class #. Bureau of Foods. Washington, DC.

Verschueren, K. 1983. *Handbook of Environmental Data on Organic Chemicals.* 2nd ed. Van Nostrand Reinhold Company, NY.

Walker, W. W. 1976. Chemical and microbiological degradation of malathion and parathion in an estuarine environment. *Journal of Environmental Quality* 5(2):210-216.

Walker, W. W. and B. J. Stojanovic. 1973. Microbial versus chemical degradation of malathion in soil. *Journal of Environmental Quality* 2(2):229-232.

Willcox, H. H. III. 1972. Progress Report of December 7. Environmental impact study of aerially applied Sevin 4-Oil on a forest and aquatic ecosystem. Lake Ontario Environmental Laboratory, Oswego, NY. Unpublished.

Wolfe, N. L., R. G. Zepp, J. A. Gordon, G. L. Baughman, and D. M. Cline. 1977. Kinetics of chemical degradation of malathion in water. *Environmental Science and Technology* 11(1):88-93.

Wolfe, N. L., R. G. Zepp, and D. F. Pacis. 1978. Carbaryl, propham, and chloropropham: a comparison of the rates of hydrolysis and photolysis with the rate of biolysis. *Water Resources* 12:565-571.

Attachment F-B

Bridges, B.A. and Mendelsohn, M. L. 1986. Genetic toxicology of environmental chemicals, Part B: genetic effects and applied mutagenesis. Alan R. Liss, Inc. pp. 51-56.

Brusick, D. J. et al. 1981. Guidelines for studies of human populations exposed to mutagenic and reproductive hazards. A. D. Bloom, ed. March of Dimes Birth Defects Foundation. pp. 111-140.

Brusick, D. J. 1987. *Principles of Genetic Toxicology.* 2nd ed. Plenum Press, NY.

Ehling, U. H. 1980. Induction of gene mutation in germ cells of the mouse. *Arch. Toxicol.* 46(1-2):123-138.

Ehling, U. H. and A. Neuhauser-Klaus. 1984. In: *Problems of Threshold in Chemical Mutagenesis.* Y. Tazima et al., eds. The Environmental Mutagen Society of Japan. pp. 15-25.

ICPEMC Committee 1 Final Report. 1983. Screening strategy for chemicals that are potential germ-cell mutagens in mammals. *Mutation Research* 114:117-177.

Russell, W. L. 1984. In: *Problems of Threshold in Chemical Mutagenesis.* Y. Tazima et al., eds. The Environmental Mutagen Society of Japan. pp. 153-160.

Russell, W. L., P. R. Hunsicker, D. A. Carpenter, C. V. Cornett, and G. M. Guinn. 1982. Effect of dose fractionation on the ethylnitrosourea induction of specific-locus mutations in mouse spermatogonia. *Proceedings of the National Academy of Sciences USA.* 79(11):3592-3593.

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G: Methods Used for Estimating Timber Volume Losses

APPENDIX G

Methods Used For Estimating Timber Volume Losses Caused By A Western Spruce Budworm Outbreak

The methods used for estimating the western spruce budworm-caused timber volume losses incorporate the use of two computer simulation models. Version 5.1 of the PROGNOSIS model for forest stand development (Stage 1973), basically a "tree-growing" model, is linked to a budworm damage submodel which was developed through the Canadian/U.S. (CANUSA) Spruce Budworm Research Program.

Tree data used in the analysis are obtained from the most current forest inventory of stand conditions. For National Forest System, State of Oregon, State of Washington, and private lands, data are taken from the latest Forest-wide inventories, most of which are updated every 10 years. Industrial forest landowners supply their own tree data for their lands, as does the Bureau of Indian Affairs for Indian Reservation analysis units.

These inventory data are segregated by the appropriate land managers into components of an overall forest yield model. The five general categories of management needs are:

1. Stands in need of regeneration
2. Stands in need of commercial thinning
3. Stands in need of precommercial thinning
4. Stands in need of overstory removal
5. Stands where no management is planned

National Forests build an average stand for each model component in one of two ways:

1. By using tree data from the first three points of all forest inventory plots which represent a particular model component

2. By selecting a subset of the inventory plots which better represents the stands in a model component in the areas being analyzed.

For National Forest lands, FORPLAN, a harvest scheduling model in use by the National Forests, is used to generate an optimum schedule of stand entries over time with the objective of maximizing present net worth of timber volume removed. An example of scheduled management needs for the Malheur National Forest is shown in Table G-I. The schedules of stand entries for State and private lands are provided by State personnel. Indian Reservation schedules are provided by the Bureau of Indian Affairs.

These inventory plot data are used as input to the stand prognosis model which was used to project volume growth over time until the final harvest. For each analysis unit, volume growth is projected for each model component using the stand prognosis model linked to the budworm damage submodel for each of several scenarios: untreated 10-year outbreak with light (U10L), moderate (U10M), or heavy (U10H) damage; treatment in the first year of visible defoliation in outbreaks projected to have light (T1 L), moderate (T1 M), or heavy (T1 H) damage, treatment in the second year of visible defoliation (T2 L, T2 M, T2 H), and so on (Table G-II). For all scenarios, it is assumed the length of the outbreak would be no longer than 10 years. Other parameters which are entered into the model include the amount of current year's defoliation for each year of the outbreak (Tables G-III through V) and the total amount of top-kill projected over the outbreak period. An example of values used for top-kill parameters for several treatment scenarios in an outbreak in which moderate damage is projected appears in Table G-VI. The volume at risk (the volume projected in a treated infestation less the volume projected for a similar untreated infestation) was estimated each decade that harvest was simulated. The total volume at risk over the rotation period (until final harvest and starting of a new stand) was then calculated for each combination of stand type, harvest type, harvest schedule, and insecticide treatment scenario. A numerical example of volumes generated by the combined models for a mixed-conifer stand on the Malheur National Forest is shown in Table G-VII.

Within each analysis unit, the acreage of each model component was totaled and multiplied by the per-acre

volume at risk. These volumes were then added together to derive the total volume at risk for the analysis unit.

TABLE G-I

FORPLAN generated optimal mix of scheduled management needs (rows) for forest yield model components (columns) using a maximum present net worth objective function for the Malheur National Forest.

	Mixed Conifer[1/]	Ponderosa Pine[2/]	Lodgepole Pine[3/]
Regeneration	Final harvest, decades 4-8	Final harvest, decades 4-8	Final harvest, decades 1-2
Commercial Thin	Overstory removal, decade 2; commercial thin decade 4; final harvest, decade 6	Overstory removal, decade 1; commercial thin decade 3; final harvest, decade 5	Overstory removal, decade 2; final harvest decade 6
Overstory Removal	Overstory removal, decades 1, 2, 3; final harvest, decades 4, 5	Overstory removal, decades 1, 2, 3; commercial thin, decades 4, 5, 6; final harvest, decades 6, 7, 8	Final harvest, decades 1, 2
No Treatment in First Decade	Overstory removal, decade 2; commercial thin, decade 4; final harvest, decade 6	Overstory removal, decade 3; final harvest, decade 6	Overstory removal, decade 2; commercial thin, decade 6; final harvest, decade 8

[1/] Stands consist primarily of Douglas-fir and grand fir.

[2/] Stands may contain up to 20 percent Douglas-fir and/or grand fir.

[3/] Stands may contain a small percentage of Douglas-fir and/or grand fir.

TABLE G-II

Insecticide treatment scenarios and the untreated scenarios with which they were compared to calculate volumes at risk for the 1988 environmental analysis of the western spruce budworm situation in the Pacific Northwest Region.

Treatment Scenario	Year(s) of Treatment [1/]	Untreated Scenario	Length of Outbreak	Projected Damage
T1 L	1	U10L	10	Light
T1 M	1,4	U10L	10	Moderate
T1 H	1,4	U10L	10	Heavy
T2 L	2	U10L	10	Light
T2 M	2,5	U10L	10	Moderate
T2 H	2,5	U10L	10	Heavy
T3 L	3	U10L	10	Light
T3 M	3,6	U10L	10	Moderate
T3 H	3,6	U10L	10	Heavy
T4 L	4	U10L	10	Light
T4 M	4,7	U10L	10	Moderate
T4 H	4,7	U10L	10	Heavy
T5 L	5	U10L	10	Light
T5 M	5	U10L	10	Moderate
T5 H	5	U10L	10	Heavy
T6 L	6	U10L	10	Light
T6 M	6	U10L	10	Moderate
T6 H	6	U10L	10	Heavy
T7 L	7	U10L	10	Light
T7 M	7	U10L	10	Moderate
T7 H	7	U10L	10	Heavy

[1/] These are the years in which insecticide treatment is projected (i.e., 2 indicates treatment in the second year that defoliation is visible during an aerial detection survey); note that some scenarios have two treatments during the course of the outbreak.

TABLE G-III

Western spruce budworm defoliation scenarios for insecticide treated and untreated Douglas-fir and grand fir in an outbreak in which light damage is predicted for the untreated scenario; 1988 analysis of the budworm situation in the Pacific Northwest Region.

	Treatment Scenario							
	U10L	T1 L	T2 L	T3 L	T4 L	T5 L	T6 L	T7 L
Year of Outbreak	Defoliation [1/]							
1	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10
2	40/50	35/45*	40/50	40/50	40/50	40/50	40/50	40/50
3	60/70	15/15	55/65*	60/70	60/70	60/70	60/70	60/70
4	70/75	25/25	15/15	65/70*	70/75	70/75	70/75	70/75
5	70/80	50/50	25/25	15/15	65/75*	70/80	70/80	70/80
6	70/75	60/60	50/50	25/25	15/15	65/70*	70/75	70/75
7	60/60	60/60	60/60	50/50	25/25	15/15	55/55*	60/60
8	50/50	50/50	50/50	50/50	50/50	25/25	15/15	45/45*
9	20/20	20/20	20/20	20/20	20/20	20/20	20/20	15/15
10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10

[1/] The number before the slash is percent defoliation of current year's foliage on Douglas-fir and the number after the slash is for grand fir; an asterisk (*) indicates insecticide treatment in that year of the outbreak.

TABLE G-IV

Western spruce budworm defoliation scenarios for insecticide treated and untreated Douglas-fir and grand fir in an outbreak in which moderate damage is predicted for the untreated scenario; 1988 analysis of the budworm situation in the Pacific Northwest Region.

	Treatment Scenario							
	U10M	T1 M	T2 M	T3 M	T4 M	T5 M	T6 M	T7 M
Year of Outbreak	Defoliation [1/]							
1	10/20	10/20	10/20	10/20	10/20	10/20	10/20	10/20
2	40/50	35/45*	40/50	40/50	40/50	40/50	40/50	40/50
3	70/80	15/15	65/75*	70/80	70/80	70/80	70/80	70/80
4	85/90	30/35	15/15	80/85*	85/90	85/90	85/90	85/90
5	85/90	65/80*	30/35	15/15	80/85*	85/90	85/90	85/90
6	85/90	15/15	65/80*	30/35	15/15	80/85*	85/90	85/90
7	85/90	30/35	15/15	65/80*	30/35	15/15	80/85*	85/90
8	50/50	65/80	30/35	15/15	45/45*	30/35	15/15	45/45*
9	20/20	20/20	20/20	20/20	15/15	20/20	20/20	15/15
10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10

[1/] The number before the slash is percent defoliation of current year's foliage on Douglas-fir and the number after the slash is for grand fir; an asterisk (*) indicates insecticide treatment in that year of the outbreak.

TABLE G-V

Western spruce budworm defoliation scenarios for insecticide treated and untreated Douglas-fir and grand fir in an outbreak in which heavy damage is predicted for the untreated scenario; 1988 analysis of the budworm situation in the Pacific Northwest Region.

Treatment Scenario3;9s								
	U10H	T1 H	T2 H	T3 H	T4 H	T5 H	T6 H	T7 H
Year of Out-break	Defoliation [1/]							
1	20/30	20/30	20/30	20/30	20/30	20/30	20/30	20/30
2	50/90	45/85*	50/90	50/90	50/90	50/90	50/90	50/90
3	80/99	15/15	75/94*	80/99	80/99	80/99	80/99	80/99
4	100/100	40/40	15/15	95/95*	100/100	100/100	100/100	100/100
5	100/100	90/90*	40/40	15/15	95/95*	100/100	100/100	100/100
6	100/100	15/15	90/90*	40/40	15/15	95/95*	100/100	100/100
7	100/100	40/40	15/15	90/90*	40/40	15/15	95/95*	100/100
8	80/99	90/90	40/40	15/15	70/89*	40/40	15/15	75/94*
9	50/50	50/150	50/50	40/40	15/15	50/50	40/40	15/15
10	10/10	10/10	10/10	10/10	10/10	10/10	10/10	10/10

[1/] The number before the slash is percent defoliation of current year's foliage on Douglas-fir and the number after the slash is for grand fir; an asterisk (*) indicates insecticide treatment in that year of the outbreak.

TABLE G-VI

Amounts of top-kill projected on Douglas-fir and grand fir for several treatment scenarios of a western spruce budworm outbreak in which the predicted damage for an untreated 10-year outbreak is classified as moderate.

	Treatment Scenario						
	U10M	T2 M	T3 M	T4 M	T5 M	T6 M	T7 M
Douglas-Fir [2/]	70/.20[1/] .77/.11 68/.10	.00/.00 .00/.00 .00/.00	.00/.00 .00/.00 .00/.00	.17/.02 .25/.02 .05/.01	.47/.04 .55/.04 .35/.02	.67/.08 .75/.07 .55/.04	.70/.20 .77/.11 .68/.10
Grand Fir	79/.06 91/.11 86/.09	.00/.00 .00/.00 .00/.00	.00/.00 .00/.00 .00/.00	.05/.01 .35/.01 .26/.01	.35/.02 .65/.02 .56/.02	.55/.04 .85/.04 .76/.04	.79/.06 .91/.11 .86/.09

1/ The number in front the slash is the projected proportion of trees that will experience top-kill; the number after the slash is the projected average proportion of the total tree height that will be killed.

2/ The top row after each tree species shows projected levels of top-kill for trees 0 to 23 feet tall, the middle row for trees 23 to 46 feet tall, and the bottom row for trees taller than 46 feet.

TABLE G-VII

Timber volumes (board feet) projected by a combined stand prognosis/budworm damage model for several insecticide treatment scenarios for a mixed conifer stand on the Malheur National Forest.

Insecticide Treatment Scenario										
Decade	U10M [1]		T4 M		T5 M		T6 M		T7 M	
1980	16332	0	16332	0	16332	0	16332	0	16332	0
1990	16552 [2]	15601	17004	14895	16849	15428	16682	15572	16554	15602
2000	1452	0	3092	0	2208	0	1713	0	1452	0
2010	2315	0	5494	0	3557	0	2946	0	2315	0
2020 [3]	4025	858	8558	2161	5651	1387	4196	1157	4025	858
2030	4632	0	8883	0	6159	0	4561	0	4632	0
2040 [4]	6860	6637	11448	11218	8416	8183	7034	6745	6859	6637
Total Volume Removed		23096		28274		24998		23474		23097

1/ Numbers in the first column under each treatment scenario heading are the standing board foot wood volumes per acre at the beginning of each decade; the second column shows the amount of volume removed each decade.

2/ Overstory removal done this decade.

3/ Commercial thinning done this decade.

4/ Regeneration (final) harvest done during this decade.

H: Monitoring of Effects of Sevin 4-Oil

APPENDIX H

Monitoring Of Effects Of Sevin 4-Oil

Abstract

In June 1979, Sevin 4-Oil was sprayed on 30,000 acres of forest on the Warm Springs Indian Reservation to control a spruce budworm infestation. Effects of the insecticide on fish and aquatic invertebrates were monitored at ten sites (three controls included) on seven streams. Spray cards indicated that Sevin 4-Oil entered the Warm Springs River, Butte Creek, and Wilson Creek. In a 12-hour period following spraying, 322,000 invertebrates drifted past monitoring sites on the Warm Springs River; 1,200 on Butte Creek. Little drift occurred in Wilson Creek. The insect orders Ephemeroptera, Diptera, Plecoptera, and Trichoptera comprised over 99 percent of the drift in both streams. All four orders decreased significantly (P.05) in post-spray bottom samples in the Warm Springs River, whereas in Butte and Wilson Creeks only, Ephemeroptera decreased significantly. Ephemeroptera and Diptera also decreased significantly in some control streams, but Plecoptera increased significantly in two control streams. Total invertebrates decreased significantly on the Warm Springs River, whereas no significant changes occurred in control streams.

The mean acetylcholinesterase activity of rainbow trout exposed to Sevin in the Warm Springs River was significantly (P.01) less (18 percent depression) than that of the control group. Catch-per-unit effort (CPUE) was greater in prespray sampling than in post-spray sampling at all sites, including controls. Increased CPUE's in post-spray sampling probably resulted from reduced streamflows which increased electrofishing efficiency. The acetylcholinesterase and CPUE results suggest that no direct fish mortality or population reduction can be attributed to the spraying program.

Introduction

In June and July of 1979, the Bureau of Indian Affairs (BIA) and the USDA Forest Service (USFS) conducted a western spruce budworm (Choristoneura occidentalis) control program on the Warm Springs Indian Reservation in north-central Oregon. Sevin 4-Oil, a carbamate insecticide, was aerially sprayed on 30,000 acres of forest. Since Sevin can be toxic to fish and aquatic invertebrates, the U.S. Fish and Wildlife Service (FWS) was contracted to monitor the effects of the spray. Prespray data on invertebrate and fish populations in seven study and three control sites were compared to post-spray data to evaluate the effects of the spraying program.

Study Area

The spray area is located in the northwest section of the Warm Springs Indian Reservation. Ten sampling sites, including three controls, were established for spray monitoring. An unnamed stream was designated No Name Creek. Normally, in a monitoring program of this type, three sampling sites are selected for each stream studied: a site within the spray area, an upstream control, and a site downstream of the spray area. In this study, however, control sites were selected on tributary streams outside the spray area because monitored streams originated within the spray area. An effort was made to select control sites similar in habitat and fish composition to the other sites. When possible, fish and invertebrates were sampled at the same location, but in some instances, stream conditions made it necessary to select separate sites.

Buffer zones extending 100 feet from both sides of the stream were marked prior to spraying on all monitored streams within the spray area. Buffer zones were to be excluded from spraying.

Nonanadromous fish species present in the spray area include rainbow trout (Salmo gairdneri), Dolly Varden (Salvelinas malma), eastern brook trout (Salvelinus fontinalis), sculpins, (Contus sp.) and dace (Rhinichthys sp.). Anadromous species present are chinook salmon (Oncorhynchus tshawytscha), and steelhead trout (Salmo gairdneri gradeneri). The insect orders Diptera, Trichoptera, Plecoptera, and Ephemeroptera comprise the majority of the aquatic invertebrates in the spray area.

The Warm Springs River and Beaver Creek rate first and second respectively in terms of anadromous fish production on the Reservation. The Warm Springs River is a major producer of spring chinook in the Deschutes River system; escapements as high as 2,500 fish were documented in 1978 by the FWS. The major spawning area for chinook in the Warm Springs River occurs in the 8 miles below Site 6B. In Beaver Creek, major chinook spawning occurs in the 2 miles of stream above Site 1B.

Spray Monitoring

Methods

Spray cards were placed along streams in the spray area to detect spray entering the streams. Generally, about eight 3- x 5-inch oil-sensitive cards were spread over a 0.5-mile section of stream near the site being monitored. Spray droplets hitting the cards appeared as white dots.

Results and Discussion

During the spraying period, spray was actually applied on 9 days. Spray cards on Butte Creek and Wilson Creek were hit lightly on June 20 and 23 respectively, and cards on the Warm Springs River were hit heavily on June 22, and again on June 25.

Although the terms lightly and heavily were used to describe the relative amount of spray hitting the cards, they may not actually reflect the relative concentration of Sevin in the stream because of the limited section of stream monitored. However, knowledge of the mere presence or absence of spray on the cards was useful in relating the biological monitoring results to effects of the spray. The following sections show that abnormally high invertebrate drift and acetylcholinestease depression occurred immediately after Sevin entered the streams.

Fish Population Monitoring

Methods

Six sites were chosen for fish monotoring: 1B, 2B, 3B, 4B, 6B, and 7F. Site 3B on Indian Creek was a "similar stream" control as described in the spray monitoring section.

Two methods were used to evaluate the effect of insecticide drift on fish populations:

1. A comparison of prespray and post-spray fish abundance;

2. Measurement of brain acetylcholinesterase activity in rainbow trout.

Fish Abundance

Prespray sampling was conducted during the first 2 weeks in June, and post-spray sampling during the second week of July. Stream sections 200 feet long were marked and blocked in both ends with 0.25-inch mesh seines to prevent escapement of fish. A Smith-Root Model VII backpack shocker was used to sample the fish populations. Salt blocks were used to enhance conductivity in some streams. One person operated the shocker, while one or two people dipnetted stunned fish. Fish were held until completion of shocking, and then counted, identified, and redistributed along the stream section. Conditions, such as the number of dip netters and use of salt blocks, were duplicated for the post-spray sampling.

An abundance index, catch-per-unit-of-effort (CPUE), was calculated for each site by dividing the number of fish caught by the seconds of electrofishing effort. CPUE values were used in comparing prespray and post-spray abundances.

Acetylcholinesterase Comparisons

Rainbow trout (mean length 3.75 in) were monitored for acetylcholinesterase depression in Butte Creek (2B), Warm Springs River (7F), and No Name Creek (8I), a control stream. Fish were held in liveboxes constructed of 0.5-inch hardware cloth which allowed fish to feed on insects drifting through. Fish were placed in the streams several days before spraying so that they could acclimate to water conditions, and to allow the removal of nonspray-related mortalities. If a stream was hit with spray, as indicated by spray cards, the fish were observed for mortalities and behavioral changes, i.e., lethargy, whirling, etc. If a heavy hit was incurred, the heads of 20 fish from the livebox were dissected, wrapped in aluminum foil, and frozen on dry ice. The samples were air-freighted to Fort Collins, Colorado, where Dr. George Post, a private consultant, analyzed them for acetylcholinesterase depression. He used a modification of the Hestin procedure, which measures the amount of acetylcholine hydrolized by 0.2 mg of brain tissue in 30 minutes. The mean brain acetylcholinesterase level of the control group was compared to the mean level in the spray hit group. The differences were compared with the Student-t test at the 95-percent confidence level.

Results and Discussion

Fish Abundance

Catch-Per-Unit-of-Effort for salmonids and nonsalmonids was greater in post-spray samples than in prespray samples in all streams monitored. Increases ranged from 7 to 19 percent for Warm Springs River (6B), Wilson Creek, Butte Creek, and Beaver Creek. CPUE increased 115 percent at Site 7F on the Warm Springs River, and 91 percent on the control stream.

Two explanations for the increase in CPUE are possible. Streamflow decreased considerably during post-spray sampling, and may have resulted in the increased CPUE's because electrofishing efficiency is greater in reduced flow situations (Beyerle and Cooper 1960). Immigration into the study sites could also have resulted in increased CPUE's. Past studies have shown that resident salmonids remain in their home areas for some or all of their lifetimes, and Stauffer (1972) reported that downstream movement of rainbow is generally over by June or July. Previous work has shown little or no movement of resident or anadromous salmonids in the Warm Springs River system in late June and July. Most of the increase in CPUE is attributed to an increase in sampling efficiency in the post-spray period.

Site 7F on the Warm Springs River probably received the highest level of Sevin. If the hit had been severe, fish mortality would have been expected. However, none occurred. CPUE data indicate that no decrease in the standing crop of fishes occurred at this site; an index of .056 fish/second for the post-spray sample compared to .026 fish/second for the prespray sample indicates an increase of 115 percent. A comparison of the rate of increase at Site 7F (115 percent) with that of control Site 3B (91 percent) further substantiates our belief that mortality did not occur. If a large fish kill had occurred at Site 7F, the rate of increase would be expected to be less than that of the control.

No immediate effects of the spray were observed in fish populations in Butte Creek and Wilson Creek, both of which were lightly hit. Increase in post-spray CPUE's for these streams was comparable to the other nonhit streams, indicating no measurable decrease in fish density.

Because of the influence of streamflows on electroschocking efficiency, small changes in fish density were undetectable. However, if severe mortalities had occurred, a substantial decrease in CPUE would have been expected in contrast to that of the control stream.

Acetylcholinesterase Comparisons

None of the trout held in liveboxes appeared stressed at any time, including those at Butte Creek which were placed in a 2.0-2.5 fps current for 0.5 hours on a day when Sevin entered the stream. Also, no wild trout were observed in distress at any time.

The heaviest insecticide drift occurred in the Warm Springs River above Site 7F. Fish held at this site and those from the control site on No Name Creek (8I) were sent to Dr. Post for acetylcholinesterase analysis. The mean brain acetylcholinesterase activity of 1.67 umol for the Warm Springs group was significantly (P.01) different from the mean value of 2.03 umol for the control group. This represents an acetylcholinesterase activity depression of 18-percent for the Warm Springs group.

The 18-percent acetylcholinesterase depression attributed to the spraying is near the low end of depression ranges found in two Maine studies where Sevin was used to control spruce budworm. Hulbert (1978) reported a range of 7 to 58 percent acetylcholinesterase depression for landlocked salmon (Salmo salar) and a range of 11 to 37 percent for brook trout (Salvelinus fontinalis). Depressions ranging from 15 to 34 percent for young-of-the-year brook trout have been reported. These fish, used in an on-site bioassay, suffered no mortalities associated with the spraying. In a third Maine study where Sevin was applied at half the usual dosage on two different dates, acetylcholinesterase levels in brook trout from treated streams were not significantly different (P.05) from levels in controls, although mean acetylcholinesterase values declined slightly over a 3-week period (Gibbs et al., 1979).

To determine the effect of acetylcholinesterase depression on a fish's stamina, calculated activity indexes for rainbow trout were subjected to different concentrations of Malathion, an organophosphate pesticide which, like carbamates, causes acetylcholinesterase depression. The activity index was calculated by adding the time it took 25 percent of a group of fish to be forced through a stamina tunnel, (velocity = 0.875 fps) to the time it took the remaining 75 percent to be forced through. The group which had a mean acetylcholinesterase depression of 18.5 percent, had an activity index equal to 97.7 percent of the control group's index. In groups subjected to higher concentrations of the pesticide, an acetylcholinesterase depression of 49.4 percent corresponded to an activity index of 66.3 percent, and a depression of 71.9 percent corresponded to an index of 29.0 percent. The near normal activity index (97.7 percent) of the group having an acetylcholinesterase depression similar to that of the rainbow trout in this

study (18 percent) concurs with observations that the fish always appeared normal.

Dr. Post concluded that "there should be little or no lasting effect of the Sevin spraying to rainbow trout held in the stream at Station 7F." Only one group of fish was analyzed at one site at one point in time. Other AchE studies have shown that AchE depressions are sometimes lower 1 week after spraying than 1 day after.

It would not be correct to say that Dr. Post concluded "that survival of the fish in the Warm Springs River system was not significantly affected by spraying."

Based upon prespray and post-spray abundance comparisons, and the low level of acetylcholinesterase depression in fish from a heavily hit stream, it was concluded that fish populations in the sprayed area were not directly affected by the spraying of Sevin.

Invertebrate Monitoring

Methods

Invertebrate monitoring was conducted at eight sites to determine the direct effect of spray operations on insect life. Sites 1B, 2B, 4B, 6B, and 7F were spray sites; sites 3B, 5I, and 8I were controls.

Invertebrate drift was measured to determine the immediate effect of the spraying. Invertebrates were collected by placing a 1-square-foot Surber sampler in the current for periods ranging from 15 minutes to 3 hours. In one instance (Site 7F), a 10-inch diameter plankton net was used in addition to the Surber sampler. The plankton net was placed in a deep, swift portion on the stream and the Surber in a slower side channel. Drift rates were standardized by calculating the number of invertebrates per hour.

One week prior to spraying, drift samples were collected at invertebrate sampling sites 1B to 8I. During the spray period, drift samples were collected at sites closest to the sprayed area. An attempt was made to obtain at least one sample before spraying commenced. Samples were then collected about every hour until spraying ceased and it was evident invertebrates were not being affected, or when the drift rate returned to prespray levels.

In two instances when Sevin entered the stream, sample drift rates were expanded to calculate the number of insects drifting past a sample site in the entire stream channel. Estimates were calculated as follows:

Effects of the spraying were also evaluated by comparing the number and weight of invertebrates present before and after spraying. Three replicate bottom samples were taken in riffle areas at invertebrate sites with a 1-square-foot Surber sampler during three periods: on June 6 and 7, 1 week prior to spraying; on July 17 and 18, about 2 weeks after completion of spraying; and on October 2, 3, and 4 about 3 months after spraying was completed.

Depending upon available time, drift and bottom samples were either picked on-site, or in the laboratory, and then preserved in 10-percent formalin. Invertebrates were later transferred to 70-percent ethanol, and identified to order, counted, and weighed to the nearest mg. Trichoptera were removed from cases before weighing. A few large drift samples were subsampled by a factor of one-tenth.

Following standard procedures, data was transformed to $\ln(x + 1)$, and a Student-t test at the 95-percent confidence level was used to test for significant differences between prespray and post-spray samples.

Results And Discussion

Drift Sampling: Abnormally high invertebrate drift was apparent at three of the sites: Site 2B on Butte Creek on June 20, and Sites 6B and 7F on the Warm Springs River on June 22.

Invertebrate drift at Site 7F on the Warm Springs River, as sampled in a slow (1 fps) side channel, increased from a prespray level of 13/hour at 0500 hours to a high of 740/hour at 0615 hours, about 1 hour after spraying commenced. The rate declined rapidly to 285/hour by 0800 hours and then more slowly to 45/hour by 1600 hours. Over 99 percent of the invertebrate drift was composed of the insect orders Ephemeroptera, Diptera, Plecoptera, and Trichoptera. Insect drift peaked at 0615 hours for all orders except Trichoptera, which peaked at 1015/hours. The highest drift rate was exhibited by Ephemeroptera (356/hour), followed by Diptera (291/hour), Plecoptera (99/hour), and Trichoptera (32/hour).

Estimates of the number of insects which drifted past Site 7I in the entire stream channel from 0400 to 1600 hours were taken. Two estimates are given: one from the Surber sampler placed in the slow side channel; the other from the plankton sampler in the main channel. Summation of the insect drift for 1-hour

intervals yields the following estimates (in thousands of insects) for the period 0400 to 1600 hours: 102-141 Ephemeroptera, 82-110 Diptera, 76-99 Plecoptera, and 15-19 Trichoptera for a total of 302-342 thousand insects.

Similarly, high drift rates were observed at Site 6B on the Warm Springs River. The Surber sampler rate declined from a high of 1,126 invertebrates/hour at 0630 hours to 156/hour at 1630 hours.

Invertebrate drift at Site 2B on Butte Creek on June 20 was considerably less than that which occurred on the Warm Springs River. Drift on Butte Creek increased from 2/hour at 0530 hours, to 29/hour at 0745 hours, about 2.5 hours after spraying started, and declined to 12/hour by 1200 hours. An estimated 1,200 insects drifted past Site 2B from 0400 to 1600 hours. Of these, Diptera comprised 43 percent, Ephemeroptera 26 percent, Trichoptera 26 percent, and Plecoptera 5 percent. Dipterans predominated the drift initially, but by 1000 hours, ephemeropterans and trichopterans predominated.

The immediate effect of Sevin on stream invertebrates is apparent from the estimated 1,200 insects which drifted past Site 2B on Butte Creek and 302,342 thousand insects which drifted past Site 7F on the Warm Springs River in a 12-hour period following spraying. In both instances, the insect drift rate peaked within 2 hours after spray cards indicated Sevin had entered the streams.

Bottom Sampling: Control streams exhibited different monthly patterns from June to October, but in no instance were the differences significant. The only significant change in streams within the spray area occurred on the Warm Springs River at Site 6B, where the numbers of total invertebrates in July and October samples were significantly less than in June samples.

Four insect orders were examined separately: Ephemeroptera, Diptera, Plecoptera, and Trichoptera. Ephemeropterans in control streams exhibited two different patterns. Ephemeropterans increased significantly in number from June to October in Cedar Swamp Creek, while they decreased significantly in Indian Creek (number and weight) and in No Name Creek (weight). In the spray area streams, ephemeropterans decreased significantly in Butte Creek in July (weight), in Wilson Creek in October (number), in the Warm Springs River at Site 6B in July (number and October (number and weight), and in the Warm Springs River at Site 7F in October (number).

Dipterans exhibited some small but significant changes in control and spray area streams. Two opposing changes occurred in control streams; dipterans increased in Indian Creek (weight) in October, but decreased in No Name Creek (number and weight) in October. Dipterans in the Warm Springs River at Site 6B decreased in number and weight in October.

Plecopterans in control streams either remained constant or increased from June to October; they increased significantly in Indian Creek in October (weight) and in Cedar Swamp Creek in July (weight) and October (number and weight). Plecopterans on the Warm Springs River at Site 6B decreased significantly in October (number).

Trichopterans in the control streams showed some changes in number and weight from June to October, but none of these differences were significant. Trichopterans decreased significantly on the Warm Springs River at Site 6B in October (weight) and increased significantly at Site 7F in July (weight).

Not all the reductions in invertebrate density which occurred within the spray area can be attributed to the application of Sevin. Because insect densities change naturally as adults emerge and young hatch, spray-related changes must be distinguished from natural ones. Establishing what natural changes have occurred becomes difficult when population changes in the control streams differ. For example, the significant decrease in Ephemeroptera which occurred on Butte Creek, Wilson Creek, and the Warm Springs River, cannot be totally attributed to the spray because ephemeropterans decreased significantly in two control streams but increased significantly in the third. Likewise, the decrease in Diptera in the Warm Springs River cannot be solely attributed to the effects of Sevin because one control increased, while another decreased.

Effects on Trichoptera were also not clearly discernible because trichopterans increased on the Warm Springs River at the site within the spray area (7I) while decreasing at the downstream site (6B).

The greatest contrast between spray area streams and control streams occurred for the order Plecoptera. Plecopterans decreased significantly at Site 6B, downstream of the spray area, while they increased significantly in two control streams. The number of total invertebrates also decreased significantly at Site 6B, whereas no significant changes in total invertebrates occurred in control streams.

Several investigators studied the effects of Sevin on stream invertebrates in Maine. Trial and Gibbs (1978) attributed short-term reductions of Ephemeroptera, Diptera, and Plecoptera to the application of Sevin. Within 2 months, Diptera and Ephemeroptera

populations had returned to prespray levels, but Plecoptera populations had not. Courtemanch and Gibbs (1977 unpublished, cited by Trial 1979) found that samples from some streams in the previous study were devoid of Plecoptera 1 year after Sevin was applied. Followup studies showed that Plecoptera had recovered by the second year in terms of number of individuals and number of taxa, but the three genera which were most numerous prior to spraying were markedly absent (Trial 1978); these conditions persisted during the third year after spraying (Trial 1979).

In our study, Plecoptera appears to be the most affected invertebrate order. It is notable however, that the mean number of Plecoptera at Site 6B on the Warm Springs River was the same in July as it was in June, and that the reduction was not observed until October when control streams showed an increase. This suggests that Plecopteran reproduction may have been affected.

Because the reproductive potential of insects is high, it is unlikely that reductions in biomass would persist. However, as some Maine studies have shown, certain insects are more susceptible to the pesticide than others, and the composition of the post-spray biomass may differ from that of the prespray biomass for some time. It would be difficult to predict what effect, if any, this could have on fish growth.

Aside from the difficulty of distinguishing spray-related effects from natural fluctuations in invertebrate density, it is apparent from the dead and moribund insects in the drift following spraying that Ephemeroptera, Diptera, Plecoptera, and Trichoptera are all affected. It is also apparent that the mortality occurred only on days when spray cards indicated that Sevin had entered the streams. Thus, adequate buffer zones should be established along streams within a spray area to reduce the danger of spray drift into the streams.

Theory and Use of Acetylcholinesterase Activity for Estimating the Effect of Carbamate Insecticides on Animals:

All higher animals, including fish, use acetylcholine to bridge the muscle nerve synapse for muscle contraction. Acetylcholine is secreted at the muscle-nerve juncture so the nerve impulse can continue into the muscle and stimulate muscle contraction. Excess acetylcholine at the muscle-nerve synapse is destroyed by the enzyme, acetylcholinesterase, otherwise muscles would remain in a state of continued contraction until completely fatigued. Reduction of acetylcholinesterase activity, because of its combination with insecticides such as the carbamates, in effect reduces the destruction of excess acetylcholine at the muscle-nerve synapse and muscle contraction until completly fatigued. Reduction of acetylcholinesterase activity, because of its combination with insecticides such as the carbamates, in effect reduces the destruction of excess acetylcholine at the muscle-nerve synapse and muscle contraction no longer functions properly. If too much acetylcholinesterase is bound by carbamate insecticides, muscle function, including heart and other vital muscles will be reduced, possibly to the point where the animal can no longer live. Small reductions in acetylcholinesterase activity will cause moderate muscle malfunction, usually manifested as loss of physical strength. There seems to be a quantitative reduction of physical strength in fishes when there is a quantitative reduction in acetylcholinesterase activity.

The measurement of acetylcholinesterase activity in any body tissue of an animal following contact with carbamate or organophosphate insecticides is a way of assessing the quantitative effect of the insecticide. Brain tissue acetylcholinesterase activity is useful for this purpose.

There are several biochemical methods for estimating loss of acetylcholinesterase activity in animal tissues. The method of Hestrin is well adapted for estimating loss of acetylcholinesterase activity in the brain tissue of fish or other animals following their contact with carbamate insecticides such as Sevin. The Hestrin procedure and its modifications actually measures the acetylcholinesterase activity of a known quantity (0.2 milligrams) of brain tissue on a known quantity of acetylcholine when incubated at 25oC (77oF) for 30 minutes.

Interpretation Of Results

The mean brain acetylcholinesterase activity of rainbow trout from the Sevin-sprayed area was 82.3 percent of the mean brain acetylcholinesterase activity of fish kept as control (nonsprayed area).

The lowest brain acetylcholinesterase found among fish from the sprayed area was 52.2 percent of the mean activity in the control fish and 63.9 percent of the control fish with the lowest (normal) brain acetylcholinesterase activity.

The data indicate moderate reduction in brain acetylcholinesterase activity among fish subjected to Sevin when compared to nontreated fish.

The treated fish with the lowest brain acetylcholinesterase activity may have lost up to a third of its physical strength. Other treated fish no

doubt had moderate loss of physical strength, none serious enough to affect survival unless placed under extreme stress.

Recovery from mild Seven intoxication by fish in the stream should be rapid. However, no data have been determined on recovery time from sublethal carbamate intoxication in fishes.

Conclusions

There should be little or no lasting effect of the Sevin spraying to rainbow trout held in the stream at Station 8I.

The reduction of brain acetylcholinesterase activity and subsequent loss of physical strength by the fish may not have been noticeable to the observer.

Recovery from the minor reduction in tissue acetylcholinesterase activity in fish held in the stream during and after spraying of Sevin should be rapid and complete.

/s/ George Post, Ph. D.

Fish & Wildlife Consultant

I: Silvicultural Discussion

APPENDIX I

Silvicultural Discussion

The western spruce budworm is an indigenous component of the Douglas-fir/true fir and mixed conifer forests of the Pacific Northwest. It is frequently found in a wide variety of forest and environmental conditions ranging from shade and ornamental trees in urban areas to forested areas. Its extensive occurrence is indicative of its broad tolerance to environmental conditions. Nevertheless, the budworm population, like all insects, is responsive to and limited by its environment. These are broad limits determined by a complex interaction of climate, site, host, predators, and the insect itself. This complexity becomes particularly important when considering manipulation of the insect's environment to regulate the insect's population levels. Add to this the vast host acreage encompassing millions of acres of commercial and noncommercial forest land, including public and private ownership, and the task of host manipulation as a method of budworm control can better be seen as a long-term forest management strategy.

The USDA Forest Service has long recognized the importance of forest management to minimize the damaging effects of forest insects and disease, especially in the forests east of the Cascade Mountains in Oregon and Washington. Over several decades, a combination of factors, including past cutting practices, fire exclusion, and management philosophy have brought about changes in the structure and composition of forests resulting in an increase of Douglas-fir and true fir, particularly true fir (Hall 1981, West 1969). White fir and grand fir forest types are recognized as having some potentially serious insect and disease problems including Douglas-fir tussock moth, western spruce budworm, root rots, and stem decay. However, on many sites in Eastern Oregon and Washington (white fir - twin flower - forb and white fir - huckleberry sites), the true firs are not only the best adapted but will out-produce other species by at least 20 percent in terms of volume production (Hall 1980, and 1981). As a result, while recognizing the increased hazard, forest management philosophy has often favored grand fir/white fir.

Over the past several years, however, recognition of the potential insect and disease problems, particularly of grand fir/white fir, has resulted in the development of the following general silvicultural prescriptions for use in considering long-term management:

1. Regenerate mature grand fir/white fir stands. High-hazard areas can be identified as composed primarily of true fir on ridge tops or steep slopes and/or having evidence of root rot pockets or severe stem decay.

a. Strive for species diversity but favor the seral species, except where grand fir/white fir is seral and root rot or stem decay has been present.

b. Avoid planting true fir. It will usually regenerate naturally but should not be allowed to exceed 30 percent of the stems per acre. Where root disease has been a problem, grand fir/white fir regeneration should be completely discriminated against.

2. Where partial cuts are necessary, favor seral species in the overstory.

a. Select the least suppressed advanced true fir regeneration for future crop trees. If advanced regeneration with wounding is present, the site should be hazard-rated for Indian paint fungus.

3. Avoid sanitation/salvage operations, especially where root rots have been present.

4. Where stocking level control is necessary, always favor mixed species. Grand fir can be favored where it is seral (again, the exception is where root rot or stem decay has been present).

This fir and mixed conifer prescription is based upon a combination of the effects of tussock moth, budworm, and disease, and focuses primarily on grand fir/white fir. For example, there is considerable information indicating the susceptibility of true fir, especially where it is climax, to pest problems. Stoszek and Mika (1978) developed a site/stand hazard rating for tussock moth which identified, among other factors, that stands comprised primarily of grand fir sustain more damage than do other stands. Williams (1967), Carolin and Coulter (1975), and Bousfield et al. (1975) have shown the greater susceptibility of true firs to budworm damage. Filip and Goheen (1985) have reported on the potentially serious problems of white fir and grand fir in their susceptibility to root

diseases such as *Phellinus weirii, Armillaria ostoyae, and Fomes annosus.* Aho (1977) found grand fir to be the most defective of the major commercial species comprising the associated species or mixed conifer types in the Blue Mountains of Oregon.

The Canadian/U.S. Spruce Budworm Program has supported studies related specifically to silvicultural management of budworm. Stoszek and Mika (1983) and Ulliman and Kessler (1983) have identified site and stand conditions related to budworm incidence. These include stand elevation, purity, average crown diameter, age, basal area, topographic position, aspect, and crown competition factors. These variables are combined in a mathematical model enabling a prediction of defoliation intensity for a given site. After initial testing, however, the model developed for use in Idaho has not been found to be generally applicable to eastern Oregon or Washington.

In the northern Rocky Mountains, Carlson et al. (1983) have found that dry Douglas-fir sites, particularly on steeper sites, are more vulnerable to budworm defoliation. This susceptibility of warm, dry habitat types has also been reported by Faus and Pierce (1969) and Stoszek and Mika (1983).

Kemp et al. (1983) have attributed outbreak frequency to lower January mean maximum temperatures, lower January mean minimum temperature, lower July mean minimum temperatures, and lower mean annual precipitation. This relationship between budworm outbreaks and weather has also been observed by Hard et al. (1980) and Twardus (1980).

The integration of these pest considerations into the long-term management of East-side National Forests has developed over the past several years. It has been a slow process, largely dependent upon information relating to pest impact and management consequences becoming available to forest managers. As the preceding literature citations have shown, much of this information has only recently become available. As pest management guidelines become available and are considered with forest management multiple-use goals and objectives, "state-of-the-art" prescriptions are being implemented on an individual stand basis. This is a long-term pest prevention solution, and it does little to alleviate the current outbreak. For as much as budworm outbreak dynamics are presently understood, the current outbreak is partially the result of several decades of forest management practices over millions of publicly and privately owned acres. From a National Forest standpoint, it will take at least that long to remedy. Even with the long-term adoption of a pest preventative management scheme, the problem would not quickly disappear.

The broad tolerance limits of the budworm population enables it to survive under varied conditions. Wherever there is Douglas-fir and true fir, particularly true fir, budworm-caused defoliation can be expected at some time. Douglas-fir and true fir will always be a component of these forests. They are commercially valuable species favored by the silvicultural practices of many industrial and nonindustrial private landowners, and are also an important component of the multiple-use objectives of National Forests (including old-growth reserves and other special designated areas). They are excellent species for intensive management, a factor which must be weighed against insect and disease problems. The key, however, is to minimize the total stand impact, not only from budworm, but from the entire pest complex of true fir. The true fir prescription, as outlined, is expected to achieve this goal where operationally and administratively possible. On some Forests, it will take an estimated 60 years to implement, but over that time, each stand treated results in that much less pest-susceptible acreage.

The use of silvicultural manipulation of forests to reduce and/or prevent western spruce budworm damage is a long-term solution and is not applicable to the current outbreak and its effects. It is an on-going process and one that will continue to be in effect regardless of decisions about future spray treatments which are made based upon this analysis.

J: Stream Classification

APPENDIX J

Stream Classification

USDA Forest Service Classification:

Class I. Perennial or intermittent streams, or segments thereof, that have one or more of the following characteristics:

Direct source of water for domestic use (FSM 2543 - cities, recreation sites, etc.).

Used by large numbers of fish for spawning, rearing, or migration.

Flow enough water to be a major contributor to the quantity of water in a another Class I stream.

Class II. Perennial or intermittent streams, or segments thereof, that have one or both of the following characteristics:

Used by moderate, though significant, numbers of fish for spawning, rearing, or migration.

Flow enough water to be a moderate or not clearly identifiable contributor to the quantity of water in Class I streams, or be a major contributor to a Class II stream.

Class III. All other perennial streams, or segments thereof, not meeting higher class criteria.

Class IV. All other intermittent streams, or segments thereof, not meeting higher class criteria.

State of Oregon Classification:

Class I. This includes USFS Class I and Class II described above.

Class II. This includes USFS Class III and Class IV described above.

State of Washington Classification:

Type 1 Water. All waters within their ordinary high-water mark as inventoried as "shorelines of the State" under Chapter 90.58 RCW, but not including those waters' associated wetlands.

Type 2 Water. Segments of natural waters having a high use and of high importance from a water quality standpoint for:

1. Domestic water supplies
2. Public recreation
3. Fish spawning, rearing or migration, or wildlife uses
4. Highly significant protection of water quality - corresponds to USFS Class I stream.

Type 3 Water. Segments of natural waters not classified as Type 1 or Type 2 having moderate to slight uses as do Type 2 waters. Corresponds to USFS Class II Stream.

Type 4 Water. Segments of natural waters not classified as Type 1, 2, or 3. Significance lies in their influence on water quality downstream on higher classified waters. Roughly corresponds with USFS Class III Stream but can be intermittent.

Type 5 Water. Segments of natural waters with or without a natural channel not classified as Type 1, 2, 3, or 4. Includes natural sinks, springs, seeps, and ephemeral streams associated with spring runoff. Roughly corresponds to USFS Class IV Stream.

K: Suppression Investments and Opportunities

APPENDIX K

Suppression Investments And Opportunities

1. Past management investments: Concern has been expressed that an economic analysis might not be sensitive to past management investments, and that benefits to be gained by these investments might be lost without special consideration.

Discussion: The economic analysis process that has been developed will recognize indirectly those past management investments which have an impact on tree growth. Timber stands with past investments are generally more intensively managed and faster growing than slower-growing, less productive, unmanaged natural stands. Because the managed stand has greater capacity for growth, it has greater potential for economic losses to forest pests. Therefore, further investment in a treatment to prevent budworm damage would avert substantially greater economic losses in the managed stand. Past management investment decisions are sunk costs; those decisions are irretrievable and not relevant to the decision at hand. The relevancy of past investments is reflected in a particular stand's growth capacity rather than in dollars that have already been spent.

2. Accomplishment of a western spruce budworm management program within current administrative constraints, which includes funding, personnel, travel, and related items:

Discussion: Implementation of the selected alternative(s) will be contingent upon landowners or land managers being able to commit the financial resources necessary to accomplish the selected course of action. If these resources are not available, implementation of the proposed alternative(s) may have to be delayed or foregone.

3. Control projects offer an opportunity to study the effects resulting from currently viable methods of integrated pest management and develop data on effects and use of promising alternative methods:

Discussion: The participating agencies recognize this opportunity to add to the present level of knowledge about currently accepted methods of pest management.

4. Reduced funding combined with anticipated high cost could reduce the effectiveness of control experienced with past projects, as well as increase the risk of poor application and accidents:

Discussion: It has been identified elsewhere in this appendix (see item 2) that implementation of any treatment project is dependent upon landowners and land managers being able to commit the necessary financial resources. Units will be treated to the extent of available funding, implementing all requirements listed in this Environmental Assessment (EA). Standards will not be sacrificed in order to treat a greater number of acres.

5. Reduced funding and constrained State budgets may require increases in private landowner share of costs or significantly limit the number of acres that can be adequately treated:

Discussion: This is a valid concern since reductions are expected in both Federal and State money for cost-sharing. Much of the burden of covering treatment costs on privately owned land may have to be placed on the landowner. Because funding appropriation is out of the Responsible Official's control, this concern is beyond the scope of this analysis and cannot be resolved herein.

6. There is some concern that improper or lax contracting procedures may permit contract awards to less than qualified firms, thereby increasing risk to the public and the environment:

Discussion: Federal regulations prohibit awarding contracts to unqualified firms.

7. Some people are concerned about the fairness-of decision criteria in determining properties to be treated or not. Who receives benefits over those who do not?

Discussion: The decision to carry out treatments based upon this analysis is the responsibility of the respective land managers. Likewise, any private landowner has the option to treat his/her land if desired, regardless of the decisions made from this analysis. Analyzing opportunities for participation in Federal and/or State cost-sharing programs is not within the scope of this analysis.

8. With reduced possibilities for cost-sharing and the adoption of multiple treatment scenarios, there is concern that State agencies of Oregon and/or Washington would be unable to implement

Infestation Control Districts requiring treatment to control the budworm:

Discussion: The designation of an Infestation Control District requiring a landowner to control a forest pest or be charged by the State to do the control, has little to do with the decision of the State to cost-share for that control. The need to consider multiple treatments rather than just one to control a pest should also have little effect on the requirement and need for control. If control of a pest requires more than one treatment in order to ensure maximum protection of a timber resource, the laws allowing for the designation of an Infestation Control District still apply. Procedures leading to implementation of these laws are beyond the scope of this analysis.

APPENDIX L

Accidents

During the 1983 budworm control project, five accidents occurred in the Pacific Northwest Region. Four involved spray helicopters, and the fifth involved a truck transporting insecticide to a helicopter batch site. One spill involving a helicopter occurred in 1985. No accidents occurred on either the Malheur or Rimrock projects in 1987. In 1988, a major helicopter accident on the Warm Springs Project resulted in the loss of life.

The potential for accidents exists whenever aircraft are used to apply pesticides. In general, there are three causes of accidents during a treatment project:

Mechanical Failure:

Accidents resulting from mechanical failure can be from loss of power needed to maintain flight, loss of maneuverability, and malfunction of the mechanisms controlling the application of the pesticide, including those involved with the emergency release system. Many mechanical-failure accidents can be prevented by rigorous maintenance and routine inspections.

The types of accidents caused by mechanical failure include: damage to the aircraft and injury or death to the pilot resulting from a forced landing, unintentional activation of the emergency release system causing unknown environmental effects, and unintentional application on nontarget areas due to faulty spray control.

Human Error:

Human error can be a major factor in the number and types of accidents that can occur during the aerial application of a pesticide. Three of the four aircraft accidents in 1983 and the spill in 1985 can be attributed to human error. The use of experienced and qualified pilots can help reduce the number of accidents caused by human error when treating a forested environment.

The types of accidents that can result from human error include: unintentional activation of the emergency release system, pilots' misjudgment causing loss of control while in-flight or during takeoff and landing, and unintentional application to nontarget areas.

Environmental Conditions:

Certain environmental conditions can result in an accident. These conditions are the least controllable. These types of accidents include: loss of control and damage to the aircraft, and creating the need for the pilot to activate the emergency release system and dumping the pesticide load.

Accidents involving pesticides can also occur during the transport and mixing of pesticides on the ground, as was the case in 1983 when a truck transporting insecticide to a helicopter batch site lost control, left the road and crashed, spilling approximately 1,900 gallons of formulated Sevin 4-Oil and diesel fuel into Willow Creek. As with aircraft, accidents on the ground can occur during a project for similar reasons:

1. Mechanical failures of equipment
2. Human error
3. Environmental conditions.

There is a potential for accidents to occur on future insect suppression projects. However, much has been learned from accidents on previous projects and has been utilized in the development of standards, guidelines, and mitigation measures. The standards, guidelines, and mitigation measures developed for these alternatives were designed to prevent, reduce the probability, and lessen the impacts of similar future incidents.

M: List of Agencies Organizations, and Persons to Whom Copies of the Environmental Impact Statement Were Sent

APPENDIX M

List of Agencies, Organizations, and Persons to Whom Copies of the Environmental Impact Statement Were Sent.

These are the agencies, organizations, and individuals who were listed to receive this EIS as of early May 1989.

Federal Agencies and Officials

Agriculture, U.S. Department of:

Agricultural Stabilization and Conservation Service, Washington, DC

Animal and Plant Health Inspection Service, Washington, DC

Architectural and Land Environmental Preeservation, Washington,DC

Centers for Disease Control, Alanta, GA

Office of Equal Opportunity, Washington, DC

Rural Electrification Administration, Washington, DC

Soil Conservation Service, Washington, DC

USDA Forest Service, Washington DC

Forest Service Regional Offices

Alaska Region, Juneau AK

Eastern Region, Milwaukee, WI

Intermountain Region, Ogden, UT

Pacific Southwest Region, San Francisco, CA

Rocky Mountain Region, Lakewood, CO

Southern Region, Atlanta, GA

Southwestern Region, Albuquerque, NM

Northern Region, Missoula, MT

National Forests

Colville

Deschutes

Fremont

Gifford Pinchot

Malheur

Mt. Baker-Snoqualmie

Mt. Hood

Ochoco

Okanogan

Olympic

Rogue River

Siskiyou

Siuslaw

Umatilla

Umpqua

Wallowa-Whitman

Wenatchee

Willamette

Winema

Experiment Stations

Pacific Northwest

Rocky Mountain

WESTFORNET-North, Seattle, WA

WESTFORNET-South, Berkeley, CA

Commerce, Department of

National Marine Fisheries Service:

Southwest Division, Terminal Island, CA

Northwest Division, Portland, OR

NOAA Ecology/Conservation Division

Defense, Department of

Army Corps of Engineers, Washington, DC

Army Corps of Engineers, Portland, OR

Army Corps of Engineers, Seattle, WA

Deputy Assistant Secretary of Defense, Washington, DC

US Air Force, Environment and Safety, Washington, DC

US Navy, Environment Protection Division, Washington, DC

Naval Oceanography Division, Naval Observatory, Washington, DC

Energy, Department of

Bonneville Power Administration, Portland, OR

Office of Environmental Compliance, Washington, DC

Richland Operation Office, Richland, WA

Environmental Protection Agency

Region IX, San Francisco, CA

Region X, Seattle, WA

Federal Energy Regulatory Commission

Office of Environmental Review, Washington, DC

Federal Highway Administration

Region 10, Portland, OR

Region 9, San Francisco, CA

Federal Railroad Administration, Washington, DC

General Services Administration, Environmental Staff, Washington, DC

Health and Human Services, Washington, DC

Housing and Urban Development, Office of Environment and Review, Washington, DC

and Region 1X

Interior, Department of

Bureau of Land Management, Portland, OR

Bureau of Indian Affairs, Portland, OR

Fish and Wildlife Service, Portland, O

Interstate Commerce Commission, Washington, DC

National Aeronautics and Space Administration, Washington, DC

National Endowment for the Arts, Washington, DC

Nuclear Regulatory Commission

Environmental Projects Office, Washington, DC

Occupational Safety and Health Administration, Washington, DC

Transportation, Department of

Environmental Division, Washington, DC

Federal Aviation Administration, Northwest Region, Seattle, WA

Federal Aviation Administration, Western Region, Los Angeles, CA

Canada

Canadian Ministry of Environment and Parks, Victoria, BC

Federal Congressional Delegation

Oregon

Senator Mark Hatfield

Senator Bob Packwood

Representative Peter Defazio

Representative Denny Smith

Representative Ron Wyden

Representative Les Aucoin

Washington

Senator Brock Adams

Senator Dan Evans

Representative Rod Chandler

Representative Norman Dicks

Representative Thomas Foley

Representative Mike Lowry

Representative Don Bonker

Representative John Miller

Representative Sid Morrison

Representative Al Swift

Oregon State Congressional Delegation

Governor

Neil Goldschmidt

Senators

Bill Bradbury
John Brenneman
Jane Cease
Joyce Cohenn
Joan Dukes
William Frye
Jeannette Hamby
Lenn Hannon
Jim Hill
Larry Hill
Cub Houck
Ken Jernstedt
Bill Kennemer
Grattan Kerans
Bob Kintigh
John Kitzhaber
William McCoy
Anthony Meeker
Rod Monroe
Bill Olson
Glenn Otto
Frank Roberts
Nancy Ryles
Jim Simmons
Eugene Timms
Clifford Trow
Jan Wyers
Mae Yih

Representatives

Verner Anserson
Bernie Agrons
Rocky Barilla
Judith Bauman
Bill Bellamy
Robert Brogoitti
Stan Bunn
Mike Burton
Ted Calouri
Larry Campbell
Margaret Carter
Ron Cease
David Dix
William Dwyer
Ron Eachus
Wayne Fawbush
Mary Ford
Ray French
George Gilman
Jeff Gilmore
Shirley Gold
Tom Hanlon
Paul Hanneman
Cedric Hayden
Darlene Hooly
Carl Hosticka
Bruce Hugo
Eldon Johnson
Peggy Jolin
Delna Jones
Denny Jones
Vera Katz
Mike Kopetski
Rick Kotulski
Bill Markham
John Schoon
Walt Schroeder
Robert Shiprack
Charles Sides
Larry Sowaf
Dick Springer
Mike Thorne
George Trahern
Liz Van Leeuwen
Tony Van Vliet
Jim Whitty
Al Young

Washington State Congressional Delegation

Governor

Booth Gardner

Senators

Ann Anderson

Cliff Bailey

Scott Barr

Albert Bauer

Dick Bender

Max Benitz

Alan Blurchel

Ted Bottiger

Emilo Cantu

Paul Conner

Ellen Craswell

Alex Deccio

Arlie Dejarnatt

George Fleming

Avery Garrett

Marcus Gaspard

Stuart Halsan

Frank Hansen

Jannette Hayner

Stanley Johnson

Bill Kiskaddon

Mike Kreidler

Eleanor Lee

Bob McCaslin

Jim McDermot

Dan McDonald

Jack Metcalf

Pat Moore

Gary Nelson

Irv Newhouse

Rad Owen

Pat Patterson

Lowell Peterson

Kent Pullen

Slim Rasmussen

Nita Rinehart

Gerald Saling

George Sellar

Bill Smitherman

Lois Stratton

Phil Talmadge

Joe Tanner

Larry Vognild

Peter Von Reichbauer

Frank Warnke

James West

Al Williams

Lorraine Wojahn

Hal Zimmerman

Representatives

Katherine Allen

Neil Amondson

Marlin Appelwick

Seth Armstrong

Clyde Ballard

Richard Barnes

Bob Basich

Forrest Baugher

John Beck

Jennifer Belcher

John Betrozoff

Dennis Braddock

Joanne Brekke

Tom Bristow

Peter Brooks

Gary Bumgarner

Maria Cantwell

Olyn Chandler

Rod Chandler

Grace Cole

David Cooper

Ernest Crane

Bill Day

Dennis Dellwo

Shirley Doty

Brian Ebersole

Roy Ferguson

Richard Fisch

Ruth Fisher
P. (Jim) Gallagher
William Grant
Daniel Grimm
Shirley Hankins
James Hargrove
Mary Haugen
Michael Heavey
Lorraine Hine
J.(Bruce) Holland
Barbara Holm
Jim Jesering
Richard King
Paul King
Joseph King
Pete Kremen
June Leonard
Jim Lewis
Gary Locke
Mike Lowry
Eugene Lux
Ken Madsen
Fred May
Alex McLean
Patrick McMullen
Ron Meyers
Louise Miller
John Miller
Sid Miller
John Moyer
Darwin Nealey
Dick Nelson
Janice Niemi
John O'Brien
Mike Padden
Michael Patrick
Kim Peery
Eugene Prince
Wes Pruitt
Marilyn Rasmussen
Margaret Rayburn
Nancy Rust
Paul Sanders
Doug Sayan
Karen Schmidt
Dick Schoon
Pat Scott
Curtis Smith
Linda Smith
Duane Sommers
Helen Sommers
Harriet Spanel
Arthur Sprenkle
Dean Sutherland
Ren Taylor
Mike Todd
Jolene Unsold
Georgette Valle
Max Vekich
George Walk
Sally Walker
Art Wang
Bob Williams
Karla Wilson
Jesse Wineberry
Shirley Winsley
Paul Zellinsky

Industry and Oranizations

Native Plant Society of Oregon
Soil Remineralization
Center Evironmental Health and Injury Control
Mt. Hood Forest Study Group
Our National Forest, Inc.
Washington Forest Protection Association
Lava Nursery, Inc.
Lane County Audubon Society
Mountain Fir Lumber Co. Inc.
Northwest Forestry Association
Washington Farm Forestry Association
Jepsen Pest Control, Inc.
Northwest Independent Forest Manufacture
Dow Chemical Company
Canadian Earthcare Society
Associated Oregon Loggers, Inc.
Boise Cascade Corporation
Mason County PUD #1
Weyerhaeuser Company
Douglas Timber Operators, Inc.
Oregon Council, Trout Unlimited
Tilth Producers Cooperative
Simpson Timber Company
Jollis, Sokol & Berstein, PC
Half-Baked Enterprises
Washington Friends of Farms & Forests
D.R. Johnson Lumber Company
NCAP

State and County Agencies

County Noxious Weed Control Board, Clackamas County, OR
California State Conservationist, Davis, CA
Washington State Conservationist, Spokane, WA
Washington State Forest Practices Board
Washington State Department of Fisheries
Washington State Department of Wildlife
Hood River County Forestry Department
County Weed District No. 1, Grant County WA
Oregon Department of Fish and Wildlife
Oregon State Department of Forestry.
Oregon State Conservationist, Portland, OR

University Libraries

Willamette Institute of Biological Control
Central Oregon Community College
Oregon State University
Blue Mountain Community College

List Of Individuals Receiving FEIS

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Ed Alverson
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Walter and Dorothty Pelech
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Gerald Pyle
Clark T. Rogerson
Sherry A. Scott
Effie Skinner
Ellen Switzer
Ethel Thornilery
John J. Townwley
Frank Vaughn
Albert L. Wellman
Richard W. Williams
E. Zahn

Individuals Affiliated With Counties, Organizations/Industry Receiving FEIS

American Fisheries Society
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Boise Casade Corporation
- Lyle K. Eddings
- James W. Harbend
- Richard D. Just
- Michael G. McGreevy
- Jerry Stroyan

Bosie Cascade Corporation
- Joel L. Tompkins
- Steve R. Tueit
- Jeffery L. Weatherly
- Steven West
- David K. Whitwill

Bureau of Water Works
- Bruce M. Niss

Chamber of Commerce
- Neal Walker

Colb River Inter-Tribal Fish Comm
- S.T. Wapato

Consep Membranes Inc
- Michael G. Banfield

Dept of Health & Human Services
- David E. Clapp

Douglas Timber Operations, Inc
- A. T. Reinhart

East Oregon Forest Protective Asso.
- Ken Shrum

Ellingson Lumber Co.
- G. Peter Ellingson

Half-Baked Enterprises
- Anthony Sowers

Hood River County
- Paul C. Bell
- Kenneth Galloway, Jr.
- Dean B. Guess
- Scott Winslo
- Dennis K. Zacha

La Grande Public Schools
- Jerry Havel

Lauterbach Forestry Services
- P.G. Lauterbach

Longview Fiber Company
- Stan Benson

Northwest Forestry Association
- Richard T. Bailey
- Bruce K. Beckett

NW Coalition for Alt. to Pesticides
- Norma Grier

Office of Environmental Project Review
- Charles S. Polityka

Oregon Department of Transportation
- D. L. Walker

Oregon State University Exten. Service
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Oregon Department of Agriculture
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Oregon Department of Forestry
- Leroy N. Kline

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Oregonians for Food and Shelter
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Prairie Wood Products
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Sierra Club; Oregon Chapter
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Western Forest Industries Assn
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N: Bibliography

APPENDIX N

Bibliography

Abbott Laboratories

1982. The Toxicology Profile

Adair, H. M. and G. J. Rich.

1977. Results of 1976 trials with Orthene for *Heliothis* control on cotton. Proceedings of the Beltwide Producers Conference. pp. 92-93.

Adams, C.H. and W.H. Cross.

1967. Insecticide resistance in *Bracon mellitor*, a parasite of the boll weevil. Journal of Economic Entomology 60(4):1016-20. (As cited in Dobroski, 1985.)

Afify, V. A.M., H.T. Farchaly, and M.H. Hassanein.

1970. Field trial studies of the effect of various insecticides on the occurrence of *entomophagous Coccinelliden* on cotton in upper Egypt. Anz Schaeclingsk, Pflanzenschutz 43(1):8-13. (As cited in Dobroski, 1985.)

Aho, P.E.

1977. Decay of grand fir in the Blue Mountains of Oregon and Washington. USDA Forest Service, Pacific Northwest Forest & Range Experiment Station Research Paper PNW-229. 18 p.

Alfaro, R. I., G. A. Van Sickle, A. J. Thomson, and E. Wegnitz.

1982. Tree mortality and radial growth losses caused by the western spruce budworm in a Douglas-fir stand in British Columbia. Can. J. For. Res. 12:780-787.

Alfaro, R.I.

1986. Mortality and Top-kill in Douglas-fir Following Defoliation by Western Spruce Budworm in B.C. J. Entomological Society of B.C. v. 83

Alvarez, C.C., H. Shimanuki, and R.J. Argauer.

1970. Oral toxicity of carbaryl to adult honey bees. Journal of Economic Entomology 63(6):1834-35. (As cited in Dobroski, 1985.)

Aly, O.M., and M.A. El-Dib.

1971. Studies on the persistence of some carbamate insecticides in the aquatic environment. I. Hydrolysis of Sevin, Baygon, Pyrolan, and Dimetilan in waters. Water Research 5:1191-1205.

Amer, S.M.

1965. Cytological effects of pesticides I. Meiotic effect of N-methyl-l-naphthyl carbamate "Sevin" on *akkium cepa.* Cytologia 30(2):175-181. (As cited in Dobroski, 1985.)

Amer, S.M. and O.R. Farrah.

1968. Cytological effects of pesticides III. Meiotic effects of N-methyl-l-naphthyl carbamate "Sevin". Cytologia 33:337-344.

American Cyanamid Company.

1986. Malathion: a review of its toxicology and environmental fate. Princeton, NJ.

American Petroleum Institute.

1983a. 28-day dermal toxicity study in the rabbit, hydrodesulfurized kerosene sample 81-07. API Medical Research Publ. 30-32297. Washington, D.C.

American Petroleum Institute.

1983b. Carcinogenic potential of key petroleum products. API Medical Research Pub. 30-31646. Washington, D.C.

American Petroleum Institute.

1983c. Index and Abstracts for Reports and Other Publications. Medicine and Biological Science Department, American Petroleum Institute. Washington, DC.

Anderson, J.W.

1975. Laboratory studies on the effects of oil on marine organisms: an overview. API Publication No. 4249. American Petroleum Institute, Washington, DC.

Arms, A. D.

1988. Oak Ridge National Laboratory, personal communication.

Arnold, J. G. and J. R. Williams.

1987. Validation of SWRRB-simulator for water resources in rural basins, Journal of Water Resource Planning and Management 113(2):243-256.

Arzone, A. and C. Vidano.

1980. Esame dell'azione sull'ape di acefate, dialifos e ziram in laboratorio (Laboratory research on the action of acephate, dialifos, and ziram on honey bees). L'Apicoltore moderno 71(2):37-43. (As cited in Lambert, 1985.)

Atallah, Y.H., W.P. Cahill, and D.M. Whitacre.

1982. Exposure of pesticide applicators and support personnel to O-ethyl O-(4-nitrophenyl) phenylphosphonothioate (EPN). Archives of Environmental Contamination and Toxicology 11:219-225.

Atkins, E.L., Jr., E.A. Greywood, and R.L. Macdonald.

1973. Toxicity of pesticides and other agricultural chemicals to honey bees. University of California Agricultural Extension, M-16 (Rev. 9/73). (As cited in Dobroski and Lambert, 1984.)

Atkins, E. L., et al.

1975. Toxicity of Pesticides and other Agricultural Chemicals to Honey Bees. Laboratory Studies. University of California, Division of Agricultural Sciences Leaflet 2287.

Barrett, G.W.

1968. The effects of an acute insecticide stress on a semienclosed grassland ecosystem. Ecology 49(6): 1019-1035

Bart, J.

1979. The effects of acephate and Sevin on forest birds. Journal of Wildlife Management 43(2):54-549.

Barthel, E.

1981. Increased risk of lung cancer in pesticide-exposed male agricultural workers. Journal of Toxicology and Environmental Health 8:1027-1040.

Bartlett, B.R.

1963. The contact toxicity of some pesticide residues to *hymenopterous* parasites and *coccinellid* predators. Journal of Economic Entomology 56(5):694-98. (As cited in Dobroski. 1985.)

Bartlett, B.R.

1966. Toxicity and acceptance of some pesticides fed to parasitic *Hymenoptera* and predatory *coccinellids*. Journal of Economic Entomology 59(5):1142-49. (As cited in Dobroski, 1985.)

Bartlett, B.R.

1968. Outbreaks of two-spotted spider-mites and cotton aphids following pesticide treatment. I. Pest stimulation vs. natural enemy destruction as the cause of outbreaks. Journal of Economic Entomology 61(1):297-303. (As cited in Dobroski, 1985.)

Batzer, H. O.

1968. Hibernation site and dispersal of spruce budworm larvae as related to damage of sapling balsam fir. Journal of Economic Entomology 61:216-220.

Beck, L.S., D.I. Hepler, and K.L. Hausen.

1982. The acute toxicology of selected petroleum hydrocarbons. Pp. 1-12. In: Macfarland, H.N., C.E. Holdsworth, J.A. MacGregor, R.W. Call, M.L. Kane (Eds.) Proceedings of the Symposium - the Toxicology of Petroleum Hydrocarbons. American Petroleum Institute. Washington, D.C.

Beckwith, R. C., and M. J. Stelzer.

1977. Persistence of *Bacillus thuringiensis* in two formulations applied by helicopter against the western spruce budworm (*Lepidoptera: Tortricidae)* in North-Central Oregon. Journal of Economic Entomology 80: 204-207.

Beckwith, Roy, M. Stelzer, and B. Hostetler.

1984. Field testing of two isolates of *Bacillus thuringiensis* against the western spruce budworm (A Progress Report). USDA Forest Service, Pacific Northwest Region Forest and Range Experiment Station, Portland, OR. 44 pp. (unpublished)

Beegle, C. C., H. T. Dulmage, D. A. Wolfenbarger, and E. Martinez.

1981. Persistence of *Bacillus thuringiensis* Berliner insecticidal activity on cotton foliage. Environ. Entomol. 10: 400-401.

Bender, M.E.

1969. Uptake and retention of malathion by the carp. Progressive Fish Culturist 31(3):155-159.

Bentz G. and A. Altwegg

1975. Safety of *Bacillus thuringiensis* for Earthworms. J. Invertebrate Pathol. 26(1):125-126.

Berteau, P. E. and R. E.Chiles.

1978. Studies on the inhalation toxicity of two phosphoramidothioate insecticides to rodents and quail. Toxicology and Applied Pharmacology 45(1):232.

Bethlahmy, N.

1973. Water Yield, Annual Peaks and Exposure in Mountainous Terrain. Journal of Hydrology, 20. Pp 155-169.

Bethlahmy, N.

1974. More Streamflow after a Bark Beetle Epidemic. Journal of Hydrology, 23. Pp 185-189.

Bethlahmy, N.

1975. A Colorado Episode: Beetle Epidemic, Ghost Forests, More Flow. Northwest Science, Vol 49, No. 2. Pp 95-105.

Biderman, J.O. and W.H. Drury.

1980. The effects of low levels of oil on aquatic birds: a nontechnical summary of research activities FY 76 through FY 78. FWS/OBS-80/16. U.S. Fish and Wildlife Service, National Coastal Ecosystems Team, Slidell, LA. (As cited in U.S. DOE, 1983.)

Bingham, F., R.P. Tosset, and D. Warshawsky.

1979. Carcinogenic potential of petroleum hydrocarbons. J. Environ. Pathology and Toxicology 3:483-563.

Blair A. and T. Thomas.

1979. Leukemia among Nebraska Farmers: a death certificate study. American Journal of Epidemiology 110(3):264-273.

Blair, A. and D. White.

1981. Death certificate study among farmers from Wisconsin. J. NCI 66(6):1027-1030.

Blair, A.

1982. Cancer risks associated with agriculture: epidemiologic evidence. In Fleck, R. and A. Hollaender. 1982. Genetic Toxicology. Plenum Publishing Corporation.

Blair, A., D. Grauman, J. Lubin, and J. Fraumeni.

1983. Lung cancer and other causes of death among licensed pesticide applicators. J. NCI 71(1):31-37.

Blair, A., H. Walker, K. Cantor, L. Burmeister, and K. Wiklund.

1985. Cancer among farmers. Scand. J. Work Environ. Health 11:397-407.

Blair, A. and D. White.

1985. Leukemia cell types and agricultural practices in Nebraska. Archives of Environmental Health 40(4):211-214.

Blias, J. R.

1983. Trends in frequency, extent, and severity of spruce budworm outbreaks in eastern Canada. Can. J. For. Res. 13:539-547.

Booth, G.M.

1975. The usefulness of model ecosystems in insecticide development. Environmental Quality and Safety Supplement 3:351-358. (As cited in Lambert, 1985.)

Borchardt, G.A.

1977. Montmorillonite and other smectite minerals. In Minerals in Soil Environments. Edited by J.B. Dixon and S.B. Weed. Soil Science Society of America Journal, Madison, WI.

Bourquin, A.W.

1977. Degradation of malathion by salt-marsh microorganisms. Applied and Environmental Microbiology 33:356-362. (As cited in Ghassemi et al., 1981.)

Bousfield, W. E., P. W. Underwood, and R.C. Lood.

1975. Western spruce budworm impact evaluation, Yoosa Creek, Clearwater National Forest, Idaho, 1974. Missoula, MT: USDA Forest Service, Northern Region; Rep. 75-20. 8p.

Bridges, B. A. and M. L. Mendelsohn.

1986. Genetic Toxicology of Environmental Chemicals, Part B: Genetic Effects and Applied Mutagenesis. Alan R. Liss, Inc., NY. Pp. 51-56

Bridgwater, D.R.

1983. Biological assessment of 1983 western spruce budworm suppression project. USDA Forest Service, Pacific Northwest Region, Forest Pest Management. Unnumbered report. 6p.

Brown, Reade E., Technical Editor.

1985. Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington. USDA Forest Service, Pacific Northwest Region, Portland, OR.

Brubaker, L.B.

1978. Effects of defoliation by Douglas-fir tussock moth on ring sequences of Douglas-fir and grand fir. Tree Ring Bulletin 38:49-50.

Brusick, D.J. et al.

1981. Guidelines for Studies of Human Populations Exposed to Mutagenic and Reproductive Hazards. A.D. Bloom, ed. March o f Dimes Birth Defects Foundation. Pp. 111-140.

Brusick, D. J., J. Ashby, F. de Serres, P. Lohman, T. Matsushima, B. Matter, M. Mendelsohn, and M. Waters.

1986. Weight of evidence scheme for evaluation and interpretation of short-term results. In: Genetic Toxicology of Environmental Chemicals, Part B: Genetic Effects and Applied Mutagenesis. Alan R. Liss, Inc., NY.

Brusick, D.J.

1987. Principles of Genetic Toxicology. Second Edition; Plenum Press, NY.

Buckman, H.O. and N.C. Brady.

1969. The Nature and Properties of Soils. The MacMillian Company, Collier-MacMillian Limited, London.

Buckner, C.H. et al.

1973 The effects of pesticides on small forest vertebrates of the Spruce Woods Provincial Forest, Manitoba. The Manitoba Entomologist 7:37-45 (As cited in Ghassemi et al., 1981.)

Buckner, C. H., P. D. Kingsbury, B. B. McLeod, K. L. Mortensen, and D. G. H. Ray.

1974. Impact of aerial treatment on nontarget organisms, Algonquin Park, Ontario and Spruce Woods, Manitoba. In: Evaluation of Commercial Preparations of *Bacillus thuringiensis* with and without Chitinase against Spruce Budworm. Information Report CC-X-59. Chemical Control Research Institute, Ottawa, Ontario, Canada.

Buikema, A.L., Jr. and A.C. Hendrick.

1980. A review. Prepared for the American Petroleum Institute. Report No. 27-33296.

Bull, D.

1978. Fate and efficacy of acephate after application to plants and insects. Journal of Agricultural and Food Chemistry 27:268-272. (As cited in U.S. Environmental Protection Agency, 1982.)

Burdick, G.E., H.F. Dean, and E.J. Harris.

1960. Effect of Sevin upon the aquatic environment. New York Fish and Game Journal 7(1):14-25. (As cited in Dobroski, 1985.)

Burges, H. D. and Bailey, L.

1971. The safety of pest-insect pathogens for beneficial insects. In: Microbial control of insects and mites (H. D. Burges and N. W. Hussey, eds.), p. 491-505. Academic Press, NY

Burks, S.L.

1982. Effects of oil on aquatic organisms. A review of selected literature. Prepared for the American Petroleum Institute, Washington, D.C. 69 pp.

Bursian, S.J. and F.W. Edens.

1977. The prolonged exposure of Japanese quail to carbaryl and its effects on growth and reproductive parameters. Bulletin of Environmental Contamination and Toxicology 17:360-368. (As cited in U.S. EPA, undated.)

Burt, W.H., and R.P. Grossenheider.

1966. A field guide to the mammals. Houghton-Mifflin, Boston, MA.

Butler, J.A., R.E. Millemann, and N.E. Stewart.

1968. Effects of the insecticide Sevin on Survival and growth of the cockle clam *Clinocardium nuttalli.* Journal of Fisheries Research Board Canada 25(8):1621-35. (As cited in Dobroski, 1985.)

Butt, J.A. (Ed.)

1968. Characterization of Spilled Oil Samples: Purpose, Sampling, Analysis, and Interpretation. The Institute of Petroleum, John Wiley and Sons, New York, NY.

Calabrese, E.J.

1978. Pollutants and High Risk Groups. John Wiley and Sons, Inc., NY.

Calabrese, E.J.

1984. Ecogenetics. John Wiley and Sons, Inc., NY.

Calabrese, E.J. and M.W. Dorsey.

1984. Healthy Living in an Unhealthy World. Simon and Schuster, NY. (Paperback, 1985).

Calabrese, E.J.

1985. Uncertainty factors and interindividual variation. Regulatory Toxicol. Pharmacol. 5:2190-196.

California Department of Fish and Game.

1963. An investigation into the effect on fish of Sevin (carbaryl) used in rice culture. PR Project W-52-R, Wildlife Investigation Laboratory, Resource Agency, California Department of Fish and Game. Unpublished.

California Department of Health Services.

1980. Assessment of health risks from the proposed aerial application of malathion in Santa Clara County. The Hazard Evaluation System and Information Service and the Pesticide Unit, Epidemiology Studies Section, California Department of Health Services.

Campbell, R. W. and T. R. Torgersen.

1982. Some effects of predaceous ants on western spruce budworm pupae in North-Central Washington. Environ. Ent. 11(1):111-114.

Cantor, K.

1982. Farming and Mortality from non-Hodgkin's lymphoma: A case-control study. Int. J. Cancer 29:239-247.

Cantor, K. and A. Blair.

1984. Farming and mortality from multiple myeloma: a case-control study with the use of death certificates. J. NCI 72(2):251-255.

Cantor, K., G. Everett, A. Blair, R. Gibson, L. Schuman, and P. Isocson.

1985. Farming and non-Hodgkin's lymphoma. Am. J. Epidemiol. 122:535.

Cantwell, G. E., D. A. Know, T. Lehnert, and A. S. Michael.

1966. Mortality of the honeybee, *Apis mellifera,* in colonies treated with certain biological insecticides. J. Invertebr. Pathol. 8:228-233.

Carlson, C. E. and W. McGaughey.

1982. Indexing western spruce budworm activity through radial increment analysis. USDA Forest Service, Research Paper INT-291. 10 p.

Carlson, C.E., D.G. Fellin, and W.C. Schmidt.

1983. The western spruce budworm in northern Rocky Mountain forests: A review of ecology, past insecticidal treatments, and silvicultural practices. In: Proceedings of Symposium on Management of Second-growth Forests. School of Forestry, University of Montana, Missoula

Carolin, V. M.

1965. Biographical notes on a green spruce budworm occurring in southern Oregon and northern California. Abstract of a paper presented at Pacific Branch, Entomol. Soc. Amer., at Monterey, CA, 1965.

Carolin, V. M. and F. W. Honinf.

1972. Western Spruce Budworm. USDA Forest Service, Forest Pest Leaflet 53.

Carolin, V. M. and W. K. Coulter.

1975. Comparison of western spruce budworm populations and damage on grand fir and Douglas-fir trees. USDA Forest Service Research Paper PNW-195, 16 p.

Carsel, R. F.

1980. Pesticide Runoff Simulator (Users Manual). Prepared for Office of Pesticides and Toxic Substances, U.S. Environmental Protection Agency Contract No. 68-01-34\840.

Carsel, R. F., C. N. Smith, L. A. Mulkey, J. D. Dean, and P. P. Jowise.

1984. Users Manual for the Pesticide Root Zone Model (PRZW) Release 1. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA. EPA/600/3-84/109.

Carter, C. O.

1977. The relative contribution of mutant genes and chromosome abnormalities to genetic ill-health in man. Progress in Genetic Toxicology Vol. II. D. Scott, B. A. Bridges, and F. H. Sobels, (eds.) Elsevier/North Holland, Amsterdam.

Casida, J.E.

1963. Mode of action of carbamates. Annual Review of Entomology 8:39-58. (As cited in Dobroski, 1985.)

Casida, J.E. and L.L. Lykken

1969. Metabolism of organic pesticide chemicals in higher plants. Annual Review of Plant Physiology 20:607-636. (As cited in Dobroski, 1985.)

Centers for Disease Control (CDC).

1987. Prevention of leading work-related diseases and injuries. Morbidity and mortality weekly report supplement. Washington, D.C.: U.S. Department of Health and Human Services.

Chevron Chemical Company.

1973. Orthene insecticide-environmental impact report. Chevron Chemical Co., Richmond, CA.

Chu, M.M.L. and D. Kamely.

1988. Environmental Cancer and Biotechnology. Biotechnology 6:675-678

Clement Associates.

1978. Relative risks of Dimilin and alternative pesticides. Clement Associates, Washington, DC.

Colburn, R. and D. Asquith.

1971. Tolerance of the stages of *Stethorus punctum* to selected insecticides and miticides. Journal of Economic Entomology 64(5)f:1072-74 (As cited in Dobroski, 1985.)

Collis, D. G. and G. A. Van Sickle.

1978. Damage appraisal cruises in spruce budworm defoliated stands of Douglas-fir in 1977. Victoria, B.C.: Environment Canada, Canadian Forestry Service; BC-P--19. 8 p.

Committee 1 Final Report.

1983. Screening strategy for chemicals that are potential germ-cell mutagens in mammals. Mutation Research 114:117-177.

Conaway, C.C., C.A. Schreiner, and S.T. Cragg.

1982. Mutagenicity evaluation of petroleum hydrocarbons. American Petroleum Institute Publication: 128-38. Report No. 30-31997

Connell, D.W. and G.J. Miller.

1984. Chemistry and Ecotoxicology of Pollution. John Wiley and Sons, NY. 444 pp.

Connor, P.F.

1960. A study of small mammals, birds, and other wildlife in an area sprayed with Sevin. New York Fish and Game Journal 7(1):26-32. (As cited in Dobroski, 1985.)

Courtemanch, D.L. and K.E. Gibbs.

1978. The effects of Sevin 4-Oil on lentic communities. In Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Main 1976 and 1977. Main Department of Conservation, Bureau of Forestry, Augusta. Pp. 141-150.

Craigmill, A. L.

1981. Malathion. Environmental Toxicology Newsletter. Cooperative Extension, University of California, Davis, CA.

Cranmer, M.F.

1986. Carbaryl: a toxicological review and risk analysis. Neurotoxicology 7(1):247-332.

Crimp, P.M.

1982. Impacts of western spruce budworm on tree growth on the eastern slope of the Washington Cascades. Seattle, WA. Univ. of Washington; 130 p. M.S. thesis.

Croft, B.A. and L.R. Jeppson.

1970. Comparative studies on four strains of *Typhlodromus occidentalis* II. Laboratory toxicity of ten compounds common to apple pest control. Journal of Economic Entomology 63(5):1528-31. (As cited in Dobroski, 1985.)

Curley, W.H. and J.M. Donohue.

1986. Risk analysis of multiple pesticide applications for the rangeland cooperative management program. Prepared for U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine. Prepared by V.J. Ciccone and Associates, VA.

Dabrowski, Z.T.

1969. Laboratory studies on the toxicity of pesticide *Typhlodromus finlandicus* and *Phytoseius macropilis*. Rocz Nauk Roln (Ser. A) 95(3):337-969. (As cited in Dobroski, 1985.)

Dabrowski, Z.T.

1970. Investigations on successive action of pesticides on the spider mites and the predatory mites populations in the apple orchards. Rocz Nauk Roln (Ser. E) 1(1):7-26. (As cited in Dobroski, 1985.)

Dabrowski, Z.T., B.H. Dabrowska, and G.S. Labanowski.

1973. Statistical evaluation of long-term effect of pesticides on predatory mites *Phytoseiidae* and *Tetranychidae* in apple orchards. Rocz Nauk Roln (Ser. E) 3:101-116. (As cited in Dobroski, 1985.)

Davies, J.E., V.H. Freed, H.F. Enos, R.C. Duncan, A. Barquet, C. Morgade, L. Peters, and J. Danauskas.

1982. Reduction of pesticide exposure with protective clothing for applicators and mixers. Journal of Occupational Medicine 24(6):464-468.

Davis, E.J., W.S. Robinson, C.F. Roush, R.D. Akre, C.A. Johansen, and W.J. Turner.

1978. Impact of chemical control applications for the Douglas-fir tussock moth on beneficial insects including biological studies of bees, yellow jackets, and flesh flies. Melanderia 30:iii-7. (As cited in Lambert, 1985.)

Davis, J.B., V.E. Farmer, R.E. Kreider, A.E. Staub, and K.M. Reese.

1972. The migration of petroleum in soil and groundwater: Principles and countermeasures. American Petroleum Institute Comm. Environmental Affairs. Publ. No. 449. Washington, DC. 36 pp.

Dennee, J.

1988. Personal Communication with Supervisor of Water Supply and Treatment Division of Utilities Department for The Dalles, OR.

Denisova, A.V.

1973. Distribution and retention time of Sevin in natural biogeocenoses. Nauchn. Osn. Okhr. Prir. 2:171-184. Article in Russian, abstract in English. (As cited in Ghassemi et al., 1981.)

Denniston, C.

1982. Low leval radiation and genetic risk estimation in man. Annual Review of Genetics 16:329-355.

DeRosa, C.T., D.H. Taylor, M.P. Farrell, and S.K. Seilkop.

1976. Effects of Sevin on the reproductive biology of the coturnix. Poultry Science 55(6):2133-2141. (As cited in U.S. EPA, undated.)

Dewey, J.E.

1969. Results of a Douglas-fir cone and seed study in Montana and Yellowstone National Park, 1968. USDA Forest Service, Northern Region. Unpublished.

Dewey, J. E.

1970. Damage to Douglas-fir cones by *Choristoneura occidentalis*. Journal of Economic Entomology 63(6):1804-1806.

Dewey, J.E.

1972. Three year evaluation of Douglas-fir cone and seed insects in Montana and Yellowstone National Park. USDA Forest Service, Northern Region, Insect and Disease Report No. 72-1.

Dewey, J. E.

1974. The western spruce budworm problem in the northern, central, and southern Rocky Mountains in 1974. In: Proceedings of a symposium on the spruce budworm. USDA Forest Service, Misc. Pub. 1327. Pp. 18-20.

DeWitt, J.B. and C.M. Menzie.

1961. Effects of Sevin on quail and pheasants. Bureau of Sport Fisheries and Wildlife, Patuxent Wildlife Research Center, Laurel, MD. (As cited in U.S. EPA, undated.)

Doane, C.C. and P.W. Schaefer.

1971. Aerial application of insecticides for control of the gypsy moth with studies of effects on nontarget insects and birds. Bulletin of Connecticut Agriculture Experimental Station, No. 724. (As cited in Dobroski, 1985.)

Dobroski, C.J., Jr. and W.P. Lambert.

1984. Malathion: A profile of its behavior in the environment. Submitted to U.S. Department of Agriculture. Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Contract No. 53-6395-1-151, submitted by Roy F. Weston, Inc., West Chester, PA.

Dobroski, C.J., Jr.

1985. Carbaryl: A profile of its behavior in the environment. Submitted to U.S. Department of Agriculture, Animal and Plant Health Inspection Service, by Roy F. Weston, Inc., West Chester, PA.

Dolinger, P.M. and W.L. Fitch.

1979. Carbaryl: Monograph number one, environmental health evaluations of California restricted insecticides. Prepared for the Environmental Assessment Team of the California Department of Food and Agriculture by Peter M. Dolinger Associates, Menlo Park, CA.

Dolph, R. E.

1980. Budworm activity, Oregon and Washington, 1947-1979. USDA Forest Service, Pacific Northwest Region, Forest Insect and Disease Mgmt., R6-FIDM-033-1980.

Dorough, H.W., N.C. Leeling, and J.E. Casida.

1963. Nonhydrolytic pathway in metabolism of N-methylcarbamate insecticides. Science 140:170-171. (As cited in Dobroski, 1985.)

Dorough, H.W. and O.G. Wiggins.

1969. Nature of water-soluble metabolites of carbaryl in bean plants and their fate in rats. Journal of Economic Entomology 64:49-53. (As cited in Dobroski, 1985.)

Doull, J., C.D. Klassen, and M.O. Amdur.

1980. Cassarett and Doull's Toxicology. 2nd ed. MacMillan Publishing Co., NY.

Dunachie, J.F. and W.W. Fletcher.

1969. An investigation of the toxicity of insecticides to birds' eggs using the egg-injection technique. Annals of Applied Biology 64:409-423.

Dutcher, J.D. and D.C. Sheppard.

1981. Predation of pecan weevil larvae by red imported fire ants. Journal of the Georgia Entomological Society 16(2):203-211.

Ehling, U.H.

1980. Arch. Toxicol. 46:123-138

Ehling, U.H. and Nenhauser-Klaus, A.

1984. Problems of Threshold in Chemical Mutagenesis. Y. Tazima et al., Eds. The Environmental Mutagen Society of Japan. Pp. 15-25.

Ehling, U. H.

1988. Quantification of the genetic risk of environmental mutagens. Risk Analysis 8:45-57.

Eichelberger, J.W. and J.J. Lichtenberg

1971. Persistence of pesticides in river water. Environmental Science and Technology 5(6):541-544.

Eid, A. et al.

1971. Toxic effects of insecticides on seeds. Agricultural Research Review 49(1):46-54. (As cited in Dobroski, 1985.)

Eidt, D. C.

1985. Toxicity of *Bacillus thuringiensis* var. *Kurstake* to aquatic insects. The Canadian Entomologist. Vol 117. Pp 829-837.

Eisenbrand, G., O. Ungerer, and R. Preussmann.

1975. The reaction of nitrate with pesticides. II. Formation. Chemical properties and carcinogenic activity of the N-nitroso derivative of N-methyl-n-napthyl carbamate (carbaryl). Food and Cosmetics Toxicology 13:365-367.

Eisenbrand, G., D. Schmahl, and R. Pruessman.

1976. Carcinogenicity in rats at high oral doses of N-nitrosocarbaryl, a nitrosated pesticide. Cancer Letters:281-284.

Elespuru, R.K. and W. Lijinsky.

1973. The formation of carcinogenic nitroso compounds from nitrite and some types of agricultural chemicals. Food and Cosmetics Toxicology 11(5):807-817.

Elespuru, R.K., W. Lijinsky, and J. Setlow.

1974. Nitrosocarbaryl as a potent mutagen of environmental significance. Nature 247:386-387.

Epstein, S.S., E. Arnold, J. Andrea, W. Bass, and Y. Bishop.

1972. Detection of chemical mutagens by the dominant lethal assay in the mouse. Toxicology and Applied Pharmacology 23:288-325.

Etter, G.E. and J. Tissier.

1973. Proprietes insecticides de deux nouveaux phosphoramidothioates: RE 9006 et RE 12420 (Insecticidal properties of two new phosphoramidothioates.) Meded Fac. Landbouwwet Rijk Gent. 38:1145-1166. (As cited in Lambert, 1985.)

Faus, D. and W.R. Pierce.

1969. Stands conditions and spruce budworm damage in a western Montana forest. J. For. 67:322-325.

Federal Register.

1984. (November 23). Office of the Federal Register, National Archives and Records Administration. U.S. Government Printing Office. Washington, DC.

Federal Register.

1986. (September 24). Office of the Federal Register, National Archive and Records Administration. U.S. Government Printing Office. Washington, DC

Felley.

1970. The effect of Sevin (1-naphthyl N-methyl carbamate) as a watershed pollutant. Ph.D. Dissertation, State University of New York, College of Environmental Science and Forestry, Syracuse, N.Y. Unpublished.

Fellin, D. G. and R. C. Shearer.

1968. Spruce budworm larvae damage western larch cones and seeds. J. For. 66(7):568-570.

Fellin, D. G. and W. C. Schmidt.

1973. Frost reduces western spruce budworm populations and damage in Montana. Agric. Meterol., 11:277-283.

Fellin, David G. and Jerald E. Dewey.

1982. Western Spruce Budworm. USDA Forest Service, Forest Insect and Disease Leaflet 53.

Fellin, D. G.

1983. Chemical insecticides vs. the western spruce budworm: After three decades, what's the score. Western Wildlands. Montana Forest and Conservation Experiment Station, University of Montana, Missoula, MT

Fellin, David G., R. C. Shearer, and C. E. Carlson.

1983. Western Spruce Budworm in the Northern Rocky Mountains. Western Wildlands 9:1 pp 2-7.

Ferrell, G. T. and R. F. Scharpf.

1982. Stem volume losses in grand firs topkilled by western spruce budworm in Idaho. USDA Forest Service Research Paper PNW-164, 10 p.

Filip, G. and D.J. Goheen.

1983. Root diseases can cause severe mortality in Pacific Northwest white and grand-fir stands. For. Sci. (In press).

Fischer, P.

1966. Effects of aircraft applications of malathion on fish and aquatic invertebrates. Parks and Wildlife Department, Austin, TX. Federal Aid Project No. F-17-R-1, Job No. 8

Fisher, R. and L. Rosner.

1959. Toxicology of the microbial insecticide, Thuricide. J. Agricul. Food Chem. 7(10):686-688.

Flavell, T. H., S. Tunnock, and H. E. Meyer.

1977. A pilot project evaluating trichlorfon and acephate for managing western spruce budworm. Helena National Forest - 1976. USDA Forest Service, Forest Insect Disease Management, Report No. 77-16. 49p.

Fleming, W.J., and S.P. Bradbury.

1981. Recovery of Cholinesterase activity in mallard ducklings administered organophosphorus pesticides. Journal of Toxicology and Environmental Health 8:885-897. (As cited in Lambert, 1985.)

Forsberg, C.W.; Henderson, M.; Henry, E.; Roberts, J.R.

1976. *Bacillus thuringiensis*: Its' effects on environmental quality. NRCC 15385. Ottawa, ON: National Research Council of Canada; 134 p.

Focht, D.D. and H. Joseph.

1974. Microbial activity in soils treated with acephate and monitor. Journal of Environmental Quality 3(4):327-328.

Franklin, Jerry F. and C. T. Dyrness.

1973. Natural vegetation of Oregon and Washington. USDA-FS General Technical Report PNW-8 417 p.

Franz, J. M., et al.

1967. Nachr. Bl. dt. Pfl. Schurtz dienst Stugg. 19:36-44

Furniss, R.L. and V.M. Carolin

1977. Western forest insects. Misc. Pub. No. 1339. U.S. Department of Agriculture, Forest Service. Washington, D.C. 654 p.

Gaddis, Philip K. and Charlotte C. Corkran

1986. Secondary effects of *B.t.* spray on avian predators: The reproductive success of chestnut-backed chickadees. Northwest Ecological Research Institute, Research Report 86-03;100 p.

Galbraith, A. F.

1973. Hydrologic Effects of Vegetation Manipulation. USDA, Forest Service, Forest Hydrology Part II, Section 2c. 38 p.

Geen, G.H., M.A. Hussain, P.C. Oloffs, and B.A. McKeown.

1981. Fate and toxicity of acephate added to a coastal British Columbia stream. Journal of Environmental Science and Health B 16:253-271. (As cited in Lambert, 1985.)

Generoso, W. et al.

1980. Mutation Research 114:117-177.

Ghassemi, M., L. Fargo, Page Painter, Pam Painter, S. Quinlivan, R. Scofield, and A. Takata.

1981. Environmental fates and impacts of major forest use pesticides. Prepared for the U.S. Environmental Protection Agency, Office of Pesticides and Toxic Substances. TRW Environmental Division, Redondo Beach, CA.

Gibbs, K.E.; C.F. Rabeni; J.G. Stanley; J.G. Trial.

1979. The effects of a split application of Sevin-4-oil on aquatic organisms. In: Environmental monitoring of cooperative spruce budworm control projects Maine, 1978. Augusta, ME: Maine Dept. of Conservation, Bureau of Forestry; 53-106.

Gibbs, K.E., T.M. Mingo, and D.L. Courtemanch.

1984. Persistence of carbaryl (Sevin 4-Oil) in woodland ponds and its effects on pond macroinvertebrates following forest spraying. Canadian Entomologist 116:203-213.

Gibson, W.P. and R.G. Burns.

1977. The breakdown of malathion in soil and soil components. Microbial Ecology 3(3):219-230.

Giles, R.H., Jr.

1970. The ecology of a small forested watershed treated with the insecticide malathion--S25.

Wildlife Monographs, No. 24

Gold, L.S. et al.

1984. Environmental Health Perspectives 58:9-319.

Golovin, M. N. and A. A. Putnam.

1962. Intertial impaction on single elements. I and E.C. Fundamentals 1(4):264-273.

Gordon, M.S., G.A. Bartholomew, A.D. Grinnell, C.B. Jorgensen, and F.N. White.

1968. Animal function: principles and adaptations. MacMillan Company, NY.

Gramlich, F.J.

1979. Effects of Sevin on songbird brain cholinesterase. In Environment Monitoring of Cooperative Spruce Budworm Control Projects. Department of Conservation, Bureau of Forestry, Augusta, ME.

Gregg, T., J. Wortendyke, D. Twardus, and J. Wear.

1979. 1976 North-Central Washington Loss Assessment Survey. USDA Forest Service, Pacific Northwest Region.

Grether, Judith K., John A. Harris, Raymond Neutra, and Kenneth W. Kizer.

1987. Exposure to Aerial Malathion Application and the Occurrence of Congenital Anomolies and Low Birthweight. American Journal of Public Health 77(8):1009-10.

Gruse, W.A. and D.R. Stevens.

1960. Chemical Technology of Petroleum. Third Edition. McGraw-Hill Book Company, Inc., New York, NY. 675 pp.

Hagstrum, D.W.

1970. Laboratory studies on the effect of several insecticides on *Tarentula kochi*. Journal of Economic Entomology 63(6):1844-47. (As cited in Dobroski, 1985.)

Haith, D.A.

1980. "A Mathematical Model for Estimating Pesticide Losses in Runoff." J. Environmental Quality 9:428-433.

Hall, Frederick C.

1973. Plant communities of the Blue Mountains in Eastern Oregon and Southeastern Washington. USDA Forest Service, Pacific Northwest Region, R-6 Area Guide 3-1.

Hall, Frederick C.

1976. Fire and vegetation in the Blue Mountains - implications for land managers. In: Proceedings, Tall Timbers fire ecology conf. (Pacific Northwest). No. 15. (Place of publication unknown): (Publisher name unknown): 277 p.

Hall, Frederick C.

1977. Ecology of natural underburning in the Blue Mountains of Oregon, R6-ECOL-79-001. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region; 11 p.

Hall, Frederick C.

1980. Fire history - Blue Mountains, Oregon. In: Proc. of the Fire History Workshop. Oct. 20-24, 1980. Tucson, Arizona. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, General Technical Report RM-81.

Hall, F. C.

1981. Ecology of grand fir. In: Proceedings of the True Fir Symposium, Seattle WA.

Hall, R.J. and E. Kole.

1980. Bioconcentration of organophosphorous pesticides to hazardous levels by amphibians. Journal of Toxicology and Environmental Health 6:853-860. (As cited in Lambert, 1985.)

Hamel, D. R.

1977. The effects of *Bacillus thuringiensis* on parasitoids of the western spruce budworm, *Choristoneura* occidentalis (Lepidoptera: Tortricidae), and the spruce coneworm, *Dioryctria reniculelloides* (Lepidoptera: Pyralidae), in Montana. Canadian Entomologist 109:1409-1415.

Hard, J. S., S. Tunnock, and R. Eder.

1980. Western spruce budworm defoliation trend relative to weather in the Northern Region, 1969-1979. USDA Forest Service, Northern Region, Rep. 80-4. USDA FS.

Harr, D. R.

1976. Forest Practices and Streamflow in Western Oregon. USDA, Forest Service, Northwest Forest and Range Experiment Station, General Technical Report PNW-46. 18 pp.

Harris, Larry D.

1984. The fragmented forest--island biogeography theory and the preservation of biotic diversity. Chicago and London: University of Chicago Press. 211 p.

Harry, J.B.

1977. A review of human exposure to Sevin, carbaryl insecticide with particular reference to the United States of America. Union Carbide Corporation. Agricultural Products Division, Salinas, CA.

Harvey, G. T.

1985. The taxonomy of the *coniferophagus Choristoneura* (Lepidoptera Tortricidae): a review. In Recent Advances in Spruce Budworms Research, Canadian Forestry Service, Ottowa, Ontario.

Harvey, R.D.

Undated. Loss Assessment, Western Spruce Budworm Infestation on the Okanogan and Wenatchee National Forests. Evaluation Report. USDA Forest Service, Pacific Northwest Region.

Hayes, A.W.

1982. Principles and Methods of Toxicology. Raven Press, NY.

Hazardous Substance Data Bank (HSDB).

1987. Kerosene, HSN 632. National Library of Medicine, Bethesda, MD.

Hazardous Substance Data Bank (HSDB).

1988. Benzo(a)pyrene, HSN 2554. National Lib. of Med., Bethesda, MD.

Helliwell, R.

1988. Memorandum to USDA Forest Service containing list of food plants on Indian Reservations and in National Forests.

Helvey, J. D. and A. R. Tiedeman.

1978. Effects of Defoliation by Douglas-fir Tussock Moth on Timing and Quality of Streamflow. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, Research Note PNW-326. 13 p.

Heywood, D.L.

1975. Degradation of carbamate insecticides in soil. Environmental Quality and Safety 4:128-133.

Hicks, M. E.

1977. Effects of Deforestation by Douglas-fir Tussock Moth on the Quality of Streamflow and the Productivity Parameters. Masters Thesis. Central Washington State College, Ellensburg, WA.

Hibbert, A. R.

1967. Forest Treatment Effects on Water Yield. In W. E. Sopper and H. W. Lull (Eds.), Int. Symp. For. Hydrology, Peramon Press, NY. Pp 537-543.

Hoerger, F. and E.E. Kenaga.

1972. Pesticide residues on plants: correlation of representative date as a basis for estimation of their magnitude in the environment. In EQS: Environmental quality and safety. Vol I. Global aspects of toxicology and technology as applied to the environment. Edited by F. Coulston. Academic Press, NY.

Hoffman, D.J. and Albers.

1984. Evaluation of potential embryo toxicity and teratogenicity of 42 herbicides, insecticides, and petroleum contaminants to mallard eggs. Arch. Environ. Contam. Toxicol. 13:15-27.

Holdsworth, R.P., Jr.

1968. Integrated control--effect on European red mite and its more important predators. Journal of Economic Entomology 61(6):1602-1607. (As cited in Dobroski, 1985.)

Honeycutt, R. C. and L. G. Ballantine.

1983. Mathematical Modeling Application to Environmental Risk Assessments. In Fate of Chemicals in the Environment, A.C.S. Symposium Series, Amercian Chemical Society, Washington, DC, Volume 255, pp. 249-262.

Horne, R.A.

1978. The Chemistry of Our Environment. John Wiley and Sons, Inc. New York, NY.

Hostetler, B. B.

1983. Biological assessment of 1982 western spruce budworm suppression project: Progress Report No. 1. USDA Forest Service, Pacific Northwest Region, Forest Pest Management. Unnumbered Report. 15p.

Huddleston, E.W., C.R. Ward, and J.L. Pulley.

1968. Spring population trands of nontarget insects following the fourth year of the high plains boll weevil control program. Entomological Reports, No. 68-2 (supplemental).

Hudson, R.H., R.K. Tucker, and M.A. Haegle.

1984. Handbook of Toxicity of Pesticides to Wildlife. 2nd ed. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Huff, J.E., R. Bates, S.L. Eustis, J.K. Haseman, and E.E. McConnell.

1985. Malathion and malaoxon: histopathology reexamination of the National Cancer Institute's carcinogenicity studies. Environmental Research 37:154-173.

Hulbert, P.J.

1978. Effects of Sevin, a spruce budworm insecticide on fish and invertebrates in the Mattawamkeas River in 1976. In Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Maine 1976 and 1977. Maine Department of Conservation, Bureau of Forestry, August, ME.

Hutchinson, V.H., W.G. Whitford, and M. Kohl.

1968. Relation of body size to gas exchange in anurans. Physiological Zoology 41:65-85.

Hussain, M.A. and P.C. Oloffs.

1980. Orthene (insecticide) residues in a creek. Proceedings of the 15th Annual Workshop for Pesticide Residue Analysts. Regina, Canada, April 30-May 2, 1980, pp. 12-23. Canadian Plains Research Center, University of Regina, Canada.

Ignoffo, C. M., D. L. Hostetter, and R. E. Pinnell.

1974. Stability of *Bacillus thuringiensis* and *Baculovirus heliothis* on soybean foliage. Environ. Entomol. 3:117-119.

Ignoffo, C.M.

1973. Effects of entomopathogens on vertebrates. Assoc. N.Y. Acad. Sci. 217:141-64.

International Technical Information Institute.

1976. Toxic and Hazardous Industrial Chemicals Safety Manual; Tokyo, Japan.

Ives, W. G. H.

1981. Environmental factors affecting 21 forest insect defoliators in Manitoba and Saskatchewan, 1945-69. Env. Can., Can. For. Serv. North. For. Res. Cent., Edmonton, Alberta. NOR-X-233.

Iwata, Y. et al.

1979. Worker environmental research: residues from carbaryl, chlorobenzilate, dimethoate, and trichlorfon applied to citrus trees. Journal of Agricultural and Food Chemistry 27:1131-1145. (As cited in Ghassemi et al., 1981.)

Jaques, R. P.

1965. The effect of *Bacillus thuringiensis* Berliner on the fauna of an apple orchard. Canadian Entomologist 97:795-802.

Johansen, C.A., E.R. Jaycox, and R. Hutt.

1963. The effect of pesticides on the alfalfa leafcutting bee, *Megachile rotundata*. Washington State University, Agriculture Experimental Station, Circular No. 418. (As cited in Dobroski, 1985.)

Johansen, C.A. and F.C. Brown.

1972. Toxicity of carbaryl-contaminated pollen collected by honey bees. Environmental Entomology 1(3):385-86. (As cited in Dobroski, 1985.)

Johansen, C.A.

1975. Bee research investigations. Washington State University Annual Report. (As cited in Lambert, 1985.)

Johansen, C.A.

1977. Pesticides and pollinators. Annual Review of Engineering 22:177-92. (As cited in Lambert, 1985.)

Johnson, D.P. and H.A. Stansbury.

1965. Adaptation of Sevin insecticide (carbaryl) residue method to various crops. Journal of Agricultural and Food Chemistry 13:235-238.

Johnson, P. C. and R. E. Denton.

1975. Outbreaks of the western spruce budworm in the American northern Rocky Mountain area from 1922 through 1971. General Technical Report INT-20. Odgen, UT: USDA, Forest Service, Intermountain Forest and Range Experiment Station; 144 p.

Johnson, W.W. and M.T. Finley

1980. Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates. U.S. Department of the Interior, Fish and Wildlife Service. Resource Publication No. 137. Washington, DC.

Joseph, S.R., J. Mallack, and L.F. George.

1972. Field applications of ultra-low-volume malathion to three animal species. Mosquito News 32:504. (As cited in Dobroski and Lambert, 1984.)

Julin, A.M. and F.J. Gramlich.

1978. Effects of Orthene on songbird brain cholinesterase in Maine, 1977 US. Department of Agriculture, Northeastern Area, State and Private Forestry, Broomall, PA, Forest Insect and Disease Management Evaluation Report, June 1978. (As cited in Lambert, 1985.)

Kalow, W. and A. Manton.

1961. Second-generation toxicity of malathion in rats. Nature 192:464-465.

Kashyap, N.P. and S.F. Hameed.

1982. Residues of some organophosphorus insecticides on peach fruits at harvest. Indian Journal of Agricultural Science 52:10-13. (As cited in Dobroski and Lambert, 1985.)

Kearby, W. H., et al.

1975. Aerial Application of *Bacillus thuringiensis* for control of the bagworm in pine plantations. J. Forestry. 73(1):29-30.

Kemp, W.P., D.G. Burnell, and D.O. Everson.

1983. Relationships between regional climate patterns and western spruce budworm outbreak frequency. CANUSA-West progress report. Portland, OR.: USDA Forest Service, Pacific Northwest Forest & Range Experiment Station 52 p.

Kenaga, E.E. and C.A. Goring.

1980. Relationship between water, solubility soil sorption, octanol-water partitioning, and concentration of chemicals in biota. Aquatic Toxicology 707:78-115. (As cited in Dobroski and Lambert, 1984.)

Kendeigh, S.C.

1970. Energy requirements for existence in relation to size of bird. The Condor 72:60-65.

Klein, W. H. and F. B. Lewis.

1966. Experimental spraying with *Bacillus thuringiensis* for control of the spruce budworm. J. For: 458-462.

Knisel, W. G. (Ed.).

1980. CREAMS: A Field-Scale Model for Chemicals, Runoff and Erosion from Agricultural Management Systems, U.S. Department of Agriculture, Conservation Research Report No. 26, 640 pp.

Kociba, R.J. and W.R. Mullison.

1985. Toxicological interactions with ag chemicals. Farm Supplier August.

Kopischke, E.D.

1972. The effect of 2,4-D and diesel fuel on egg hatchability. Journal of Wildlife Management 36:1355-1356. (As cited in U.S. DOE, 1983.)

Krieg, A. and W. Herts.

1962. Entomophaga. Mem hors Ser. No. 2:193-195.

Krieg, A. and W. Herts

1963. Entomologia Exp. Appl. 6: 1-9.

Krieg, A. and G. A. Langenbruch

1981. Susceptibility of arthropod species to *Bacillus thuringiensis*. Appendix 1, pp. 837-896 in Burges, H. D. (Ed), Microbial Control of Pests and Plant Diseases 1970-1980. Academic Press, London.

Kucera, Emil.

1987. Brain Cholinesterase Activity in Birds After a City-Wide Application of Malathion. Bull. Environ. Contam. Toxicol. 38:456-460.

Kuhr, R.J. and J.E. Casida.

1967. Persistent glycosides of metabolites of methylcarbamate insecticide chemicals formed by hydroxylation in bean plants. Journal of Agricultural and Food Chemistry 13:537-543. (As cited in Dobroski, 1985.)

Kupetz, Von H., G. Neider, and H. Wegner.

1979. Ergebnisse von untersuchungen zur bienengefahrlichkeit und beinentoxizitat von pflanzenschutzmitteln und der en wirkstoffen (Results of studies on the toxicity to bees of plant protective agents and their effects). Pflanzenschutzverichte 45(7-12):165-188. (As cited in Lambert, 1985.)

Kutz, F., A. Yobs, and H. Yang.

1976. National pesticide monitoring programs. In Air Pollution from Pesticides and Agricultural Processes, pp. 95-137. Edited by R. Lee. CRC Press, Cleveland, OH. (As cited in Dolinger and Fitch, 1979.)

Ladd, J.N.

1956. The oxidation of hydrocarbons by soil bacteria: I. Morphological and biochemical properties of a soil Diptheroid utilizing hydrocarbons. Australian Journal of Biological Sciences 9:92.

LaFleur, K.

1976. Movement of carbaryl through Conjaree soil into groundwater. Journal of Environmental Quality 5:91-92.

Lagier, R.F. et al.

1974. Adjuvents decrease insecticide hazard to honey bees. Washington State University, College of Agriculture Research Center Bulletin No. 801. 7 pp.

Lake Ontario Environmental Laboratory (LOTEL).

1975. Environmental impact study of aerially applied Orthene on a forest and aquatic ecosystem. Lake Ontario Environmental Laboratory, State University College, Oswego, NY.

Lake Ontario Environmental Laboratory (LOTEL).

1977. The environmental impact of Sevin-4-oil (carbaryl) on a forest and aquatic ecosystem. SUNY Lake Ontario Environmental Laboratory, Oswego NY. LOTEL Rep. 215. 128 p.

Lambert, W.P.

1985. Orthene: profile of its behavior in the environment. Submitted to the U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Contract No. 53-6395-1-151.

Lamberton, J.G. and R.R. Claeys.

1970. Degradation of 1-naphthol in sea water. Journal of Agricultural and Food Chemistry 18(1):92-96.

Larson, L.

1975. The selective toxicity of Orthene. Dissertation, University of California, Riverside, CA (As cited in Lambert, 1985.)

Lasiewski, R.C. and W.A. Calder Jr.

1971. A preliminary allometric analysis of respiratory variables in nesting birds. Respiration Physiology 11:152-166

Lavy, T. L., J. S. Shepard, and J. D. Mattice.

1980. Exposure measurements of applicators spraying (2,4,5-trichlosophenosy) acetic acid in the forest. Journal of Agricultural and Food Chemistry 28:626-630.

Law Engineering Testing Company.

1982. Review of ground-water models. Prepared for American PetroleumInstitute. Washington, DC 69 pp.

Leonard, D. E. and G. A. Simmons.

1974. The effects of Zectran on the parasitoids of the spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). Canadian Entomologist 106:545-554.

Leonard, R. A., W. G. Knisel, and D. A. Shill.

1987. GLEAMS: groundwater loading effects of agricultural management systems. Transactions of the ASAE 30(5):1403-1418.

Lewis, F. B.

1960. Factors affecting assessment of parasitization by *Apanteles fumiferanae* Vier. and *Glypta fumiferanae* (Vier.) on spruce budworm larvae. Canadian Entomologist 92:881-891.

Lichenstein, E.P., K.R. Schulz, R.F. Skrentny, and Y. Tsukano.

1966. Toxicity and fate of insecticide residues in water. Archives of Environmental Health 12:199-212.

Lijinsky, W. and H. V. Taylor.

1976. The effect of substituents on the carcinogenicity of N-nitrosopyrrolidine in Sprague-Dawley rats. Cancer Research 36(6):1988-1990.

Lijinsky, W. and D. Schmahl.

1978. Carcinogenicity of N-nitroso derivatives of N-methyl carbamate insecticides in rats. Ecotoxicology and Environmental Safety 2:413-419.

Lijinsky, W. and C. Winter.

1981. Skin tumors induced by painting nitrosoalkylureas on mouse skin. Journal of Cancer Research and Clinical Oncology 102:13-20.

Lindsten, A., W. J. Buckhorn, J. F. Wear, J. M. Whiteside, and K. H. Wright.

1949. Spruce budworm situation in Oregon and Washington--1949 season. USDA, Bur. Entomol. & Plant Quar., Portland, OR. Unnumbered Report, Sept. 1, 1949. 27 p. + appendix.

Liu, S.Y. and J.M. Bollag.

1971. Carbaryl decomposition to 1-Napthyl Carbamate by *Aspergillus terreus*. Pesticide Biochemistry and Physiology 1:366-372.

Livingston, R.L., J.W. Schwandt, J. Preston, W. Ciesla, B. Davidek, D. Beckman, L. Spickelmire, R. Johnson.

1982. 1979 western spruce budworm control project, Cascade, ID. Idaho Dept. of Lands Report No. 82-4. 64 pp.

Loomis, T.A.

1978. Essentials of Toxicology. Lea and Febiger, Philadelphia, PA.

Lyman, W.J., W.F. Reehl, and D.H. Rosenblatt (eds.)

1981. Research and Development of Methods for Estimating Physico-Chemical Properties of Organic Compounds of Environmental Concern. Report No. C-82426 by Arthur D. Little, Inc. under contract DAMD-17-78-C-0873, U.S. Army Medical R&D Command, Ft. Detrick.

Lyman, W.J. et al.

1982. (As cited in Dobroski, 1985.)

Lyons, D.R., C.H. Buckner, B.B. Mcleod, and K.M.S. Sundaram.

1976. The effects of fenitrothion, matacil, and Orthene on frog larvae. Ottawa, Ontario: Chemical Control Research Institute, Report CC-X-129, November 1976. (As cited in Lambert, 1985.)

Mabey, W.R., J.H. Smith, R.T. Podoll, H.L. Johnson, T. Mill, T.W. Chou, J. Gates, I. Waight Partridge, H. Jaber, and D. Vanderberg.

1982. Aquatic fate process data for organic priority pollutants: final report. Prepared by SRI International for the U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC. EPA Contract No. 68-01-3867/68-03-2981

MacLean, D. A.

1985. Effects of spruce budworm outbreaks on forest growth and yield. Recent Advances in Spruce Budworm Research, Canadian Forestry Service, Ottawa, Ontario.

Macler, F. J. and R. P. Beliles.

1979. Teratology study in rats. Diesel fuel final report. American Petroleum Institute Medical Research Publication No. 27-32174.

MacPhee, A.W. and K.H. Sanford.

1961. The influence of spray programs on the fauna of apple orchards in Nova Scotia. XII. Second supplement to VII. Effects on beneficial arthropods. Canadian Entomologist 93:671-73. (As cited in Dobroski, 1985.)

Mann, G.S. and S.L. Chopra.

1969. Residues of carbaryl on crops. Pesticides Monitoring Journal 2:163-165.

Manser, P.D. and F.D. Bennett.

1963. Possible effects of the application of malathion on the small moth borer, *Diptraea saccharalis* and its parasite *Liophaga diatraea* in Jamaica. Bulletin of Entomological Research 53:75-82. (As cited in Dobroski and Lambert, 1984.)

Marancik, J.

1976. Effect of insecticides used for spruce budworm control in 1975 on fish. In 1975 cooperative pilot control project of Dylax, Matacil, and Sumithon for spruce bodworm control in Maine, pp. 11-34. U.S. Department of Agriculture, Forest Service Northeast Area, State and Private Forest Insect District Management, Upper Darby, PA, August 1976.

Marzulli, F.N. and H.I. Maibach.

1973. Antimicrobials: experimental contact sensitization in man. Journal of the Society of Cosmetic Chemistry. 24:399-421. (As cited in IARC, 1982.)

Marzulli, F.N. and H.I. Maibach.

1983. Dermatotoxicology. (2nd ed.) Hemisphere Publishing Company, Washington, DC. 693 pp.

Maser, Chris; James M. Trappe, and Douglas C. Ure.

1978. Implications of small mammal mycophagy to the management of western coniferous forests. In: Sabol, Kenneth, ed. Transactions of the forty-third North American wildlife and natural resources conference; 1978 March 18-22; Phoenix, AZ. Washington, D.C: Wildlife Management Institute: 78-88.

Matsumura, F. and G.M. Baush.

1966. Malathion degradation by *Trichoderma viride* and a *Pseudomonas* species. Science 153(3741):1278-1280.

Matsunaga, E.

1982. Perspectives in mutation epidemiology: incidence and prevalence of genetic diseases (excluding chromosomal aberrations) in human populations. Mutation Research 99:95-128.

Maxwell, R.C.

1982. Meaning of label signal words. Pesticide Report 43:4-5. Washington State University, Cooperative Extension Service, Pullman, WA (As cited in Walstad and Dost, 1984.)

Mayland, P.G. and C.C. Burkhardt.

1970. Honey bee mortality as related to insecticide-treated surfaces and bee age. Journal of Economic Entomology 63(5):1437-39. (As cited in Dobroski, 1985.)

Mayer, F.L., Jr. and M.R. Ellersieck.

1986. Manual of acute toxicity: Interpretation and data base for 410 chemicals and 66 species of freshwater animals. Resource Publication 160. U.S. Department of Interior, Fish and Wildlife Service, Washington, DC.

McCullough, R.D. and J.G. Stanley.

1980. Effects of carbaryl (Sevin) on brook trout in streams receiving drift from spraying of nearby forests. Maine Cooperation of Fisheries Research Unit, University of Maine, Orono, ME.

McEwen, L. C., J.F. MacDonald, J.E. Peterson, et al.

1962. The effects of Sevin on sharp-tailed grouse and waterfowl at the Lostwood Wildlife Refuge, North Dakota. Annual Progress Report, U.S. Department of the Interior, Denver Wildlife Research Center, Wildlife Research Work Unit. (As cited in Dobroski, 1985.)

McEwen, L.C. and L.R. DeWeese.

1981. Summary of 1981 field studies of acephate effects on rangeland wildlife. U.S. Fish and Wildlife Service, Fort Collins, CO (Animal and Plant Health Inspection Service--Final Environmental Impact Statement.) Unpublished.

McGaughey, William H.

1985. Insect resistance to biological insecticide *Bacillus thuringiensis*. Science. 229:193-195.

McKusick, V. A.

1983. Mendelian Inheritance in Man. 6th ed. Johns Hopkins University Press, Baltimore.

Melzian, B.D.

1983. Acute toxicity, histopathy, and bioconcentration. Retention studies with No. 2 fuel oil and the blue crab, Callinectes sapidus Rathbun. Dissertation. Abstracts International B: The Sciences and Engineering. 43 (1).

Miller, C. A. and T. R. Renault.

1976. Incidence of parasitoids attacking endemic spruce budworm (Lepidoptera: Tortricidae) populations in New Brunswick. Canadian Entomologist 108:1045-1052.

Miller, Jeffrey C.

1986. Impact of *B.t.* applications for the control of the gypsy moth in Oregon: Effects on nontarget Lepidoptera. Oregon Department of Agriculture. Final Report 6 p.

Millers, E.

1976. Evaluation of 1 pound and 1/2 pound Sevin-4-Oil applications for spruce budworm control in Minnesota, 1975. USDA Forest Service, Northeastern Region, State and Private Forestry, Forest Insect Disease Management, Upper Darby, PA. Eval. Rep. S-23-76. 12 p.

Mishan, E.J.

1976. Cost-benefit Analysis. Praeger Publishers. NY

Moeller, H.G. and J.A. Rider

1962. Plasma and red blood cell cholinesterase activity as indicators of the threshold of incipient toxicity of ethyl-p-nitrophenyl thionobenzene phosphonate (EPN) and malathion in human beings. Toxicology and Applied Pharmacology. 4:123-130.

Moeller, F.E.

1972. Honey bee collection of corn pollen reduced by feeding pollen in the hive. American Bee Journal 112(6):210-12. (As cited in Dobroski, 1985.)

Moffett, J.O., W.T. Wilson, A. Stoner, and A. Wardecker.

1979. Journal of Economic Entomology 72(3):453-455. (As cited in Lambert, 1985.)

Mommsen, S. and J. Aagard.

1984. Occupational exposures as risk indicator of male bladder carcinoma in a predominantly rural area. Acta. Radiol. 23(2-3):147-52.

Moore, J. A. (Ed.)

1964. Physiology of the Amphibia. Academic Press, NY

Morris, O. N.

1977. Long-term study of the effectiveness of aerial applications of *Bacillus thuringiensis* - acephate combinations against the spruce budworm, Choristoneura fumiferana (Lepidoptera: Tortricidae). Canadian Entomologist 109:1239-1248.

Morrison, R.T. and R.N. Boyd.

1974. Organic Chemistry; 34d Edition. Allyn and Bacon, Inc. Boston, MA

Moulding, J.D.

1972. The impact on forest bird and nontarget arthropod populations of the use of the insecticide Sevin for gypsy moth control. Rutgers University; Ph.D. thesis. Unpublished.

Mount and Oehme.

1981. (As cited in U.S. Fish and Wildlife Service, 1986.)

Mounts, J., R. E. Dolph, D. McComb, and T. F. Gregg.

1978. 1977 western spruce budworm control project in North-Central Washington. USDA Forest Service, Pacific Northwest Region 33p.

Mulla, M.S. and L.S. Mian.

1981. Biological and environmental impacts of the insecticides malathion and parathion on nontarget biota in aquatic ecosystems. Residue Reviews 78:101-135.

Muncy, R.J. and A.D. Oliver, Jr.

1963. Toxicity of ten insecticides to the red crawfish, *Procambarus clarki* (Girard). Transactions of American Fisheries Society 91:428-431. (As cited in Dobroski and Lambert, 1984.)

Murphy, S.D.

1980. Pesticides. In Cassarrett and Doull's Toxicology. Edited by J. Doull, C. Klassen, and M. Amdur. MacMillan Publishing Company, NY.

Murray, F.J., R.F. Staples, and B.A. Schwetz.

1979. Teratogenic potential of carbaryl given to rabbits and mice by gavage or by dietary inclusion. Toxicology and Applied Pharmacology 51:81-89.

Murray, H.E. and R.K. Guthrie.

1980. Effects of carbaryl, diazinon, and malathion on native aquatic populations of microorganisms. Bulletin of Environmental Contamination and Toxicology 24(4):535-32. (As cited in Dobroski, 1985).

Musgrave, R.A., and P.B. Musgrave.

1973. Public Finance in Theory and Practice. McGraw-Hill, Inc. NY

National Academy of Sciences.

1977. Drinking Water and Health. Safe Drinking Water Committee, Advisory Center on Toxicology, Assembly of Life Sciences, National Research Council, National Academy of Sciences, Washington, DC. 939 pp.

National Cancer Institute.

1978. Bioassay of malathion for possible carcinogenicity. DHEW Publication No. (NIH) 78-824.

National Cancer Institute.

1979a. Bioassay of malathion for possible carcinogenicity. NIH Publication No. 79-1748.

National Cancer Institute.

1979b. Bioassay of malaoxon for possible carcinogenicity. NIH Publication No. 79-1390.

National Library of Medicine (NLM).

1986. Off-line printout on malathion from Hazardous Substances Data Bank. Bethesda, MD.

National Library of Medicine (NLM)

1986b. Off-line printout on carbaryl from Toxnet toxicology data bank. Bethesda, MD.

National Library of Medicine (NLM).

1987a. Off-line printout on methamidophos from Hazardous Substances Data Bank. Bethesda, MD.

National Library of Medicine (NLM).

1987b. Off-line printout on kerosene, HSN 632, from Hazardous Substances Data Bank, Bethesda, MD.

National Research Council (NRC).

1977. Drinking Water and Health. National Academy Press, Washington, DC.

National Research Council (NRC).

1982. Diet, Nutrition, and Cancer. National Academy Press, Wash. DC.

National Research Council--Committee on the Institutional Means for Assessment of Risks to Public Health (NRC Committee).

1983. Risk assessment in the Federal Government: managing the process. Washington D.C: National Academy Press. 191 p.

National Research Council (NRC).

1985. Injury in America: A Continuing Public Health Problem. National Academy Press, Washington, D.C.

National Research Council (NRC).

1986. Drinking Water and Health. Volume 6. Thomas, R.D. (Ed.) National Academy Press. Washington, DC.

National Research Council (NRC).

1987. Regulating Pesticides in Food: The Delaney Paradox. National Academy Press. Washington, DC.

Newmann, H.J.; B. Paczynska-Lahme, and D. Severin.

1981. Composition and properties of petroleum. Geology of Petroleum. Vol. 5 H. Beckman, ed. Halsted Press, New York.

Newton, M. and L. A. Norris.

1981. Potential exposure of humans to 2,4,5-T and TCDD in the Oregon coast ranges. Fundamental and Applied Toxicology 1:339-346.

Nigg, H.N., J.A. Reinert, J.H. Stamper, and G.E. Fitzpatrick.

1981. Disappearance of acephate, methamidophos, and malathion from citrus foliage. Bulletin of Environmental Contamination and Toxicology 26(2):267-272.

Niwa, C.G., M. J. Stelzer, and R. C. Beckwith.

1987. Effects of *Bacillus thuringiensis* on parasites of western spruce budworm (Lepidoptera: Tortricidae). Journal of Economic Entomology 80: pp.50-753.

Ogle, John

1988. Agriculture Canada. Personal Communication

Oregon State Department of Fish and Wildlife Memorandum of Understanding

Management Strategies and Common Goals.

Oregon State Forest Practices Act.

Oregon State Department of Human Resources.

1987. Oregon Vital Statistics - County Data, 1986. Center for Health Statistics. Portland, OR.

Parcell, J.

1988. Personal communication with Forest Service Soil Scientist.

Pascal, D.C. and M.E. Neville.

1976. Chemical and microbial degradation of malaoxon in an Illinois soil. Journal of Environmental Quality 5(4):441-443.

Pednekar, M.O., S.R. Ganhi, and M.S. Netzawali.

1987. Evaluation of Mutagenic Activities of Endosulfan, Phosalone, Malathion, and Permethrin, Before and After Metabolic Activation, in the Ames Samonella Test. Bulletin of Environmental Contaminant Toxicology 38:925-33.

Pet-Edwards, J., W. Chankong, H. S. Rosenkranz, and Y. Y. Haines.

1985. Application of the carcinogenicity prediction and battery selection (CPBS) method to the Gene-Tox data base. Mutation Research 153:187-200.

Peterson, B., D. Palmer, and R. Ryder.

1981. The effects of acephate on rangeland wildlife. Colorado State University, Fishery and Wildlife Biology Department, Fort Collins, CO. Unpublished. (As cited in U.S. EPA, 1984d.)

Pfadt, R.E., N.L. Marston, and F.A. Lawson.

1985. Effect of ULV malathion grasshopper spray on nontarget arthropods. Science Monograph 48. Agricultural Experiment Station, University of Wyoming, Laramie, WY.

Pieper, G.W.

1979. Residue analysis of carbaryl on forest foliage and in stream water using HPLC. Bulletin of Environmental Contamination and Toxicology 22:167-171. (As cited in Ghassemi et al., 1981.)

Plapp, F.W., Jr. and S.B. Vinson.

1977. Comparative toxicities of some insecticides to the tobacco budworm and its ichneumonid parasite, Campoletis sonorensis. Environmental Entomology 6(3):381-84. (As citied in Dobroski, 1985.)

Popendorf, W.J.

1985. "Advances in the Unified Field Model for Reentry Hazards." In Dermal Exposure Related to Pesticide Use: Discussion of Risk Assessment, B.C. Honeycutt, G. Zweig, and N.N. Ragsdale (eds.). Washington, DC. ACS symposium series 273.

Popendorf, W.J. and J.T. Leffingwell.

1982. "Regulating OP Pesticide Residues for Farm Worker Protection." Residue Rev. 82:125-201.

Potts, D. F.

1984. Hydrologic Impacts of a Large-scale Mountain Pine Beetle (Dendroctonus Ponderosae Hopkins) Epidemic. Water Resources Bulletin, Vol. 20, No. 3. American Water Resources Association. Pp 373-377.

Qayum, A.

1982. Social Cost-benefit Analysis. The HaPi Press. Portland, OR

Rabeni, C.F.

1978. The impact of Orthene, a spruce budworm control project, Maine 1976 and 1977. Maine Department of Conservation, Bureau of Forestry, Augusta, ME.

Rabeni, C.F. and K.E. Gibbs.

1979. The impact of Orthene, a spruce budworm insecticide on aquatic macroinvertebrates in Maine, 1977. U.S Department of Agriculture, Forest Service. Rep. NA-FR-7.

Ragenovich, I. R.

1986. Synopsis of the 1985 Western Spruce Budworm Operational Evaluation using *Bacillus thuringienses* on the Malheur National Forest, Oregon. USDA Forest Service, Pacific Northwest Region, Forest Pest Management. Unpublished report.

Rao, G.S., K. Kannan, S.K. Goel, K.P. Pandya, and R. Shanker.

1984. Subcutaneous kerosine toxicity in albino rats. Environ. Res. 35(2):516-530.

Reardon, R., D. Cahill, and R. W. Thier.

1984. Implantation and injection of systematic chemical insecticides in Douglas-fir in Idaho to increase seed yield. USDA Forest Service, Intermountain Region. FPM Report No. 84-6 9 p.

Registry of Toxic Effects of Chemical Substances (RTECS).

1987. U.S. Department of Health, Education, and Welfare. NIOSH/LP8-925000.

Reinert, J. C. and D. J. Severn.

1985. Dermal exposure to pesticides: the Environmental Protection Agency's viewpoint. In Dermal Exposure Related to Pesticide Use: Discussion of Risk Assessment. ACS Symposium Series, Washington, DC.

Richmond, M.L., C.J. Henny, R.L. Floyd, R.W. Mannan, D.M. Finch, and L.R. DeWeese.

1979. Effects of Sevin 4-Oil, Dimilin, and Orthene on forest birds in northeastern Oregon. U.S. Department of Agriculture, Pacific Southwest Forest and Range Experiment Station, Research Paper PSW-148, September. (As cited in Lambert, 1985.)

Rickard, R.W., G. Walter-Echols, H.W. Dorough, and L.J. Lawrence.

1982. Importance of pH in assessing the potential for nitrosocarbamate formation in the stomach. Pesticide Biochemistry and Physiology 18(3):325-333. (As cited in Cranmer, 1986.)

Robbins, C.S., B. Bruun, H.S. Zim, and A. Singer.

1966. A guide to field identification: birds of North America. Golden Press, NY

Robertson, J.L. and L.M. Boeller.

1979. Toxicity of insecticides to Douglas-fir tussock moth, *Orgyia pseudotsugata* (Lepidoptera: Lymantriidae) II. Residual toxicity and rainfastness. Canadian Entomologist 111:1161-1175. (As cited in Lambert, 1985.)

Robertson, J. L. and M. W. Stock.

1985. Toxicological and electrophoretic population characteristics of western spruce budworm, *Choristoneura* occidentalis (Lepidoptera: Tortricidae). Canadian Entomologist 117:57-65.

Robinson, W.S. and C.A. Johansen.

1978. Effects of control chemicals for Douglas-fir tussock moths *Orgyia pseudotsugata* (McDonnough) on forest pollination (Lepidoptera: Lymantriidae). Melanderia 30:9-56. (As cited in Lambert, 1985.)

Romine, R.R. and R.A. Bussian.

1971. The degradation of carbaryl after surface application to a farm pond. Union Carbide Project Report 111A13. Unpublished.

Root, R.B. and J.J. Skelsey.

1969. Biotic factors involved in crucifer aphid outbreaks following insecticide application. Journal of Economic Entomology 62(1):223-33. (As cited in Dobroski, 1985.)

Rose, A.

1988. Personal communication with manufacturer of acephate.

Rosenberg, A. and M. Alexander.

1979. Microbial cleavage of various organophosphorous insecticides. Applied and Environmental Microbiology 37:886-891. (As cited in U.S. Environmental Protection Agency, 1982.)

Rosgen, D. L., H. L. Silvey, and J. P. Potyondy.

1986. The Use of Channel Maintenance Flow Concepts in the Forest Service. Hydrological Science and Technology: Short Papers, Vol. 2, No. 1, March 1986. American Institute of Hydrology. Pp 19-26.

Rousch, C.F. and R.D. Akre.

1978. Impact of chemical for control of the Douglas-fir tussock moth upon populations of ants and yellowjackets (Hymenopter: Formicidae, Vespidae). Melanderia 30:95-110. (As cited in Lambert, 1985.)

Routh, J.I., D.P. Eyman and D.J. Burton.

1971. A Brief Introduction to General, Organic, and Biochemistry. W.B. Sanders Co., Philadelphia, Pennsylvania. 459 pp.

Russell, L.B. et al.

1981. Mutation Research 86:329-354.

Russell, L. B., C. S. Aaron, F. de Serres, W. M. Generoso, K. L. Kannan, M. Shelby, J. Springer, and P. Voytek.

1984. Evaluation of existing mutagenicity bioassays for purposes of genetic risk assessment. Mutation Research 134:143-157.

Russell, W.L. et al.

1982. Proc. Nat. Acad. Sci. USA 79:3592-3593.

Russell, W.L.

1984. Problems of Threshold in Chemical Mutagenesis. Y. Tazima et al., eds. The Environmental Mutagen Society of Japan. pp. 153-160.

Saini, M.I. and W.H. Dobough.

1970. Persistence of malathion and methyl parathion when applied as ultra-low-volume and emulsifiable concentration sprays. Journal of Economic Entomology 63:405-408.

Saleh, S.M., et al.

1970. Fate of *bacillus thuringiensis* in soil: effect of soil pH and organic amendment. Can. J. Microbiol. 16:667-680.

Sandquist, R.E.; T.F. Gregg

1985. Personal communication. USDA-Forest Service, Pacific Northwest Reg.

Sassaman, J.F.

1987. Pesticide Background Statements: *Bacillus thuringiensis*. U.S. Department of Agriculture, Forest Service, Forest Pest Management, Porland, OR.

Satpathy, J.M., G.K. Padhi, and D.N. Dutta.

1968. Toxicity of eight insecticides to the coccinellid predator *Chilomenes secmaculata*. Indian Journal of Entomology 30(Pt. 2):130-32. (As cited in Dobroski, 1985.)

Scharf, S.M., D. Heimer, and J. Goldstein.

1981. Pathologic and physiologic effects of aspiration of hydrocarbons in the rat. Am. Rev. Respir. Div. 124(5):625-629.

Schmidt, J.L. and D.L. Gilbert.

1978. Big game of North America. Stackpole, Harrisburg, PA

Schmidt, W. C.

1981. Forests of the Rocky Mountain West. In: Effects of Fire on Flora a state-of-knowledge review. Gen. Tech. Rep. WO-16. USDA FS.

Schmidt-Nielsen, K.

1972. How animals work. Cambridge University Press.

Schoettger, R.A. and W.L. Mauck.

1976. Toxicity of experimental forest insecticides to fish and aquatic invertebrates. Fish--Pesticide Research Laboratory, U.S. Fish and Wildlife Service, Columbia, MO.

Scott, D. R. M. and T. J. Nichols.

1983. Growth impacts on host trees due to western spruce budworm defoliation on the east slope of the Washington Cascades. Unpublished final report to CANUSA/Spruce Budworm Research Program--West.

Scott, V.E., K.E. Evans, D.R. Patton and C.P. Stone.

1977. Cavity nesting birds of North American forests. U.S. Dept. Agriculture Handbook No. 511.

Sedell, J. R. and K. J. Luchessa

1981. Using the historical records as an aid to salmonid habitat enhancement. In: Proceedings of a Symposium on Acquisition and Utilization of Aquatic habitat Inventory Information. Western Division Amer. Fish. Soc. Oct. 28-30, 1981. Portland, OR pp. 210-222.

Sell, C.R. and J.C. Maitlen.

1980. Report of residue analysis: carbaryl, apple leaves, and worker exposure samples, agricultural worker exposure to pesticides PCY-80-1, No. 5805-20250-003. USDA, Yakima, WA. (As cited in Ghassemi et al., 1981.)

Shelby, M. D.

1988. The genetic toxicity of human carcinogens and its implications. Mutation Research 204:3-15.

Shepard, M. and W. Sterling.

1972. Effects of early season applications of insecticides on beneficial insects and spiders in cotton. Texas Agricultural Experiment Station Bulletin MP-1045. (As cited in Dobroski, 1985.)

Shepherd, R., J. Harris, A. Van Sickle, L. Fiddick, and L. McMullen.

1977. Status of western spruce budworm on Douglas-fir in British Columbia. Environment Canada, Forestry Service, Pacific Forest Research Center, Pest Report. 14 p.

Silvey, H. L.

1973. Hydrologic Effects of Vegetation Manipulation. USDA Forest Service, Forest Hydrology Part II, Section 2a-b. 61 p.

Sinclair, R.L.

1968. Effects of quail, migratory birds, and nongame birds on aerial applications of malathion and other insecticides. Job Completion Report, Federal Aid in Wildlife Act, Texas, Federal Aid Project No. W-88-R-7.

Smalley, H.E., J.M. Gurtis, and F.L. Earl.

1968. Teratogenic action of carbaryl in beagle dogs. Toxicology and Applied Pharmacology 13:392-403

Smirnoff, W. A. and A. M. Heimpel.

1961. J. Insect. Pathol. 3:403-408.

Smirnoff, W. A.

1979. Results of spraying *Bacillus thuringiensis* two consecutiveyears over balsam fir stands damaged by spruce budworm. Can. J. For. Res. 9:509-513.

Smirnoff, W. A.

1983. Residual effects of *Bacillus thuringiensis* and chemical insecticide treatments on spruce budworm Chonstoneura fumiferana (Clemons). Crop Protection. 2(2):225-230.

Smith, Gregory J.

1987. Pesticide Use and Toxicology in Relation to Wildlife: Organophosphorus and Carbamate Compounds.

Spacie, A. and J.L. Hamelink.

1985. Bioaccumulation, Chapter 17, pp. 495-525 in Fundamentals of Aquatic Toxiology. G.M. Rand and S.R. Petrocelli (Eds.) Hemisphere Publishing Corporation. New York, NY.

Sprague, J.B.

1985. Factors that modify toxicity. In Fundamentals of Aquatic Toxicology. Rand, G.M. and S.R. Petrocelli (Eds.) Hemisphere Publishing Corporation. NY.

Speight, J.E.

1980. The Chemistry and Technology of Petroleum. Marcel and Depper, Inc., New York, NY.

Stadnyk L., R.S. Campbell, and B.T. Johnson.

1971. Pesticide effect on growth and 14C assimilation in a freshwater alga. Bulletin of Environmental Contamination and Toxicology 6(1):1-8. (As cited in Dobroski, 1985.)

Stage, A.R.

1973. Prognosis model for stand development. USDA Forest Service, Intermountain Region. Research Paper INT-137.

Starek, A. and M. Kaminski.

1981. Comparative studies on toxicity of various dielectrics, petroleum derivatives, used in electroerosion technology. IV. Morphological and cytoenzymatic changes in the lungs and acid-base imbalance in rats chronically exposed to petroleum hydrocarbons. Med. Pr. 32(2):69-81.

Starek, A. and M. Kaminski.

1982. Comparative studies on the toxicity of various dielectrics--petroleum derivitives used in the electroerosion technique. V. Functional, morphological, and cytoenzymatic charges in the kidneys of rats chronically exposed to petroleum hydrocarbons. Med. Pr. 32(2):69-81

Stelzes, L.R.

1982. Corporate communication between Chevron Chemical Company and the U.S. Environmental Protection Agency. 18 January 1982. (As cited in Lambert, 1985.)

Stern, V.M.

1963. The effect of various insecticides on *Trichogramma semifunatum* and certain predators in southern California. Journal of Economic Entomology 56:348-50. (As cited in Dobroski, 1985.)

Stern, V.M., R. Van den Bosch, and H.T. Reynolds

1959. Effects of Dylox and other insecticides on entomophagous insects attacking field crop pests in California. Journal of Economic Entomology 53:67-72. (As cited in Dobroski, 1985).

Stevenson, J.H.

1970. Laboratory and field assessment of pesticide poisoning of honeybees. Proceedings of the 5th British Insecticide and Fungicide Conference 2:378-85. (As cited in Dobroski, 1985.)

Stewart, N.E., R.E. Millemann, and W.P. Breese.

1967. Acute toxicity of the insecticide Sevin and its hydrolytic product 1-napthol to some marine organisms. Transactions of American Fisheries Society 96(1):25-30. (As cited in Dobroski, 1985.)

Stipe et al.

1977. (Stipe, L. E., J. A. E. Knopf, R. L. Livingston, R. W. Young, and G. P. Markin. 1977). A cooperative pilot project to evaluate Orthene Forest Spray for control of the western spruce budworm, *Choristoneura occidentalis* Freeman (Lepidoptera: Tortricidae). McCall, ID. USDA Forest Service, Intermountain Region 34 p. + Appendix; and Anonymous, 1975, (Interim report, 1975 field test with Orthene 75S against the western spruce budworm in North-Central Washington. USDA Forest Service, Pacific Northwest Region. Unpublished report.); and initial small-scale suppression projects (Livingston et al, 1982 [Livingston, R. L., J. W. Schwandt, J. Preston, W. Ciesla, B. Davidek, D. Beckman, L. Spickelmire, and R. Johnson. 1982]. 1979 western spruce budworm control project, Cascade, ID. Idaho Department of Lands Report No. 82-4. 64p.).

Stipe, L. E., C. G. Niva, R. G. Eder, K. E. Gibson, and H. W. Meyer.

1983. Pilot project of *Bacillus thuringiensis* against western spruce budworm in Central Montana. USDA Forest Service, Northern Region Forest Pest Mgmt. Rep. 83-4. 69 p.

Stoszek, L.K.; and P.G. Mika.

1978. Forest Management Considerations; Interpreting Hazard Conditions. The Douglas-Fir Tussock Moth: A Synthesis. USDA-Forest Service Science and Education Agency, Tech. Bull. 1585, p 190-93.

Stoszek, L.K. and P.G. Mika.

1983. The relationships of western spruce budworm outbreaks to site/stand attributes, development and management history: model completion and comparison. CANUSA-West final report. Moscow, ID: College of Forestry, Wildlife and Range Sciences, Univ. of Idaho. 70 p.

Stock, M. W. and J. L. Robertson.

1984. Predicting response of forest defoliators to insecticides. In: Research in Forest Productivity, Use, and Pest Control. USDA Forest Service, Northeastern Area, General Technical Report NE-90.

Strang, G.E., J. Nowakowski, and R.A. Morse.

1968. Further observations on the effect of carbaryl on honey bees. Journal of Economic Entomology 61(4):1103-1104. (As cited in Dobroski, 1985.)

Sutherland, J. and T.A. Woods, et al.

1977. Pesticide Phytotoxicity. Con. for Serv. Pacific Forest Research Census Report. BC-X 186. (As cited in Dobroski, 1985.)

Szaro, R.C., P.H. Alblers, and N.C. Coon.

1978. Petroleum: effects on mallard egg hatchability. Journal of Wildlife Management 42:404-406.

Szeto, S.Y., H.R. McCarthy, P.C. Oleffs, and R.F. Shepherd.

1979. The fate of acephate and carbaryl in water. Journal of Environmental Science and Health 14(6):635-654.

Tagatz, M.E., P.W. Borthwick, G.H. Cook, and D.L. Coppage.

1974. Effects of ground applications of malathion on saltmarsh environment in northwestern Florida. Mosq. News 34:39. (As cited in Mulla and Mian, 1981.)

Telfer, W. G.

1983. Western spruce budworm suppression and evaluation project using carbaryl, 1977. USDA Forest Service, Southwest Region, Albuquerque, NM. Progress Report No. 6.

Thomas, J.W., ed.

1979. Wildlife habitats in managed forests, the Blue Mountains of Oregon and Washington. Agric. Handb. WO-553. Washington, DC: USDA-Forest Service; 512 p.

Thomson, W.T.

1979. Agricultural Chemicals, Book I: Insecticides, Acaricides, and Ovicides. 1979-80 Rev. Thomson Publications. Fresno, CA.

Tilden, R.L. and Ch. H. van Middelem.

1970. Determination of carbaryl as an amide derivative by electroncapture gas chromatography. Journal of Agricultural and Food Chemistry 18:154-158. (As cited in Ghassemi et al., 1981.)

Todd, I. S. and K. J. Jackson.

1961. The effects on salmon of a program of forest insect control with DDT on Northern Moresby Island. Canada Fish Culture 30:15-38, in Reference 31.

Toia, R.F., R.B. March, N. Umetsu, N.M. Mallipudi, R. Allahyari, and T.R. Fukuto

1980. Identification and toxicological evaluation of impurities in technical malathion and fenthion. Journal of Agricultural and Food Chemistry 28(3):599-604

Toll, L.

1988. Personal Communication with Water Master of The Dalles, OR.

Tompkins, W.A.

1966. Sevin residues in marine and freshwater aquatic organisms. In report of the surveillance program conducted in connection with an application of carbaryl (Sevin) for the control of gypsy moth on Cape Cod, Massachusetts. Committee of Massachusetts, Massachusetts Pesticide Board Publication. 547,37-46. (As cited in Dobroski,1985.)

Torgersen, T. R., R. W. Campbell, N. Srivastava, and R. C. Beckwith.

1984. Role of parasites in the population dynamics of the western spruce budworm (Lepidoptera: Tortricidae) in the Northwest. Environ. Entomol. 13:568-573.

Travis, C. C. and A. D. Arms.

1988. Bioconcentration of organics in beef, milk, and vegetation. Environmental Science and Technology 22(3):271-274.

Trial, J.G.

1978. The effects of Sevin 4-Oil on aquatic insect communities of streams: a continuation of 1976 studies. In Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Maine 1976 and 1977. Maine Department of Conservation, Bureau of Forestry, Augusta, ME. Pp. 124-140.

Trial, J.G.; K.E. Gibbs

1978. Effects of Orthene, Seven-4-oil, and Dylox on aquatic insects incidental to attempts to control spruce budworm in Maine, 1976. In: Environmental monitoring of cooperative spruce budworm control projects, Maine 1976 and 1977. Augusta, ME.: Maine Dept. of Conservation, Bureau of Forestry; p 207-16.

Trial, J.G.

1979. The effects of Sevin 4-Oil on aquatic insect communities of streams (1976-1978). In Environmental Monitoring of Cooperative Spruce Budworm Control Projects, Maine 1978. Maine Department of Conservation, Bureau of Forestry, Augusta, ME. Pp. 6-22.

Trondle, C. A. and H. L. Gary.

1982. Snow Accumulation and Melt Under Various Stand Densities in Lodgepole Pine in Wyoming and Colorado. USDA Forest Service, Rocky Mountain Region Forest and Range Experiment Station, Research Note RM-417. 7 p

Tucker, B.V.

1972. Orthene leaching in soil. Chevron Chemical Co., Richmond, CA. (As cited in U.S. Environmental Protection Agency, 1982.)

Twardus, D.B.

1980. Evaluation of weather patterns in relation to western spruce budworm outbreak in North-Central Washington, 1970-1980. USDA Forest Service, Pacific Northwest Region, Forest Insect & Disease Mgmt. Unnumbered Report. 16 p.

Twardus, D.B.

1982. Evaluation of weather patterns in relation to western spruce budworm outbreak in north-central Washington, 1970-1980. USDA Forest Service, Forest Insect and Disease Mgmt., Pacific Northwest Region, Portland, OR.

Ukeles, R.

1962. Growth of pure cultures of marine phytoplankton in the presence of toxicants. Applied Microbiology 10(6):532-37. (As cited in Dobroski, 1985.)

Ulliman, J.J. and B.L. Kessler.

1983. Validation of a spruce budworm aerial photo/risk model. CANUSA-West final report. Portland, OR: USDA Forest Service, CANUSA-West Spruce Budworms Program. 87 p.

Union Carbide.

1978. Sevin 4-Oil application and handling booklet (Revised edition). Jacksonville, FL.

Union Carbide.

1980. A review of Sevin--carbaryl insecticide. Union Carbide Agricultural Products Company, Inc., Jacksonville, FL. (As cited in Dobroski, 1985.)

Union Carbide.

1981. Human exposure from aerial spraying of Sevin 4-Oil carbaryl insecticide. Technical Information Bulletin, Union Carbide Agricultural Products Company, Inc., Jacksonville, FL. (As cited in Dobroski, 1985.)

Union Carbide.

1982. Sevin 50-W label information. Institute, West Virginia

U.S. Bureau of the Census.

1987. Statistical abstract of the United States 1988. U.S. Dept. of Commerce, Washington, D.C.

U.S. Bureau of Land Management (BLM).

1987. Final environmental impact statement: Northwest Area Noxious Weed Control Program. U.S. Department of Interior, Washington, DC.

U. S. Department of Agriculture (USDA)

1976. Northern region: pilot project to evaluate Dylox and Orthene for controling the western spruce budworm-environmental analysis report. Helena National Forest.

U.S. Department of Agriculture (USDA), Agricultural Research Service.

1967. Protecting honey bees from pesticides. U.S. Department of Agriculture Leaflet No. 544. (As cited in Dobroski, 1985.)

U.S. Department of Agriculture (USDA), Agricultural Research Service.

1977. Pesticides and honey bees. U.S. Department of Agriculture Leaflet No. 563. (As cited in Dobroski, 1985.)

U.S. Department of Agriculture (USDA), Forest Service

1975. Interim Report 1975 Field Test with Orthene 75S against the western spruce budworm in North-Central Washington. (Unpublished Report).

U.S. Department of Agriculture (USDA), Forest Service.

1979. Soil Resource Inventory, Mt. Hood National Forest, Forest Service, Pacific Northwest Region, 312 pp.

U.S. Department of Agriculture (USDA), Forest Service.

1980. An Approach to Water Resources Evaluation of Non-point Silivicultural Sources (A Procedural Handbook). Prepared for Environmental Research Lab, Athens, GA.

U.S. Department of Agriculture (USDA), Forest Service

Forest Service Handbook Title 1907.17. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service

Forest Service Handbook Title 1909.15. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service

Forest Service Handbook Title 2509.17. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Hydrology, Part II - Region 6, Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Service Manual Title 1922. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Service Manual Title 1971.71. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Service Manual Title 2320. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Service Manual Title 2324.1. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Service Manual Title 2543. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Service Manual Title 2670. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

1981. Forest Service Manual Title 3400. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

Forest Service Manual Title 3422. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

1984. Pesticide Background Statements, Volume I: Herbicides. Agricultural Handbook No. 633, Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

1984 Western Spruce Budworm Management - Northeast Oregon. Environmental Assessment, 1984.

U.S. Department of Agriculture (USDA), Forest Service.

1984 Fish and Wildlife Annual Report.

U.S. Department of Agriculture (USDA), Forest Service.

1985. Gypsy moth suppression and eradication projects: Final Environmental Impact Statement. Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service

1985(a). Managing Trees and Stands Susceptible to Western Spruce Budworm. U. S. Forest Service Technical Bulletin No. 1695, Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

1985(b). Predators of the Spruce Budworm. U. S. Forest Service Agriculture Handbook No. 644, Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

1987(a). Western Spruce Budworm Management in Oregon and Washington during 1987. Environmental Assessment for U. S. Forest Service, Wash., DC.

U.S. Department of Agriculture (USDA), Forest Service.

1987(b). Western Spruce Budworm. U. S. Forest Service Technical Bulletin No. 1694, Washington, DC.

U.S. Department of Agriculture (USDA), Forest Service.

1988. Letter from A.J. West to Regional Foresters, Station Directors, and Area Directors regarding biological pesticide Dioburden.

U.S. Department of Agriculture (USDA), Forest Service

1988. Environmental Analysis (EA). Western Spruce Budworm Management in Oregon and Washington During 1988. USDA, Forest Service, Pacific Northwest Region (R-6). Pp 45-46.

U.S. Department of Agriculture, Forest Service and Animal Plant Health Inspection Service.

1984. Final Environmental Impact Statement: Gypsy Moth Suppression and Eradication Projects.

U.S. Department of Agriculture, Soil Conservation Service.

1972. SCS National Engineering Handbook-Section 4 Hydrology.

U.S. Department of Energy, Bonneville Power Administration.

1983. Final Environmental Impact Statement: Transmission Facilities Vegetation Management Program. Bonneville Power Administration. DOE/EIS-0097-F. U.S. Department of Energy, U.S. Government of Printing Office, Washington, D.C. 464 pp. and appendices.

U.S. Department of Health, Education, and Welfare.

1976. Criteria for recommended standards...occupational exposure to malathion. Public Health Service, National Institute for Occupational Safety and Health. Report No. NIOSH-76-205.

U.S. Department of Health and Human Services.

1985. Fourth annual report on carcinogens. Summary 1985. Public Health Service. NTP 85-002.

U.S. Department of Health and Human Services.

1987. "Prevention of Leading Work Related Diseases and Injuries" Morbidity and Mortality Weekly Report. Centers for Disease Control. U.S. Government Printing Office, Washington D.C.

U.S. Department of the Interior.

1963. Pesticide wildlife studies--a review of fish and wildlife service investigations during the calendar year. U.S. Department of the Interior Circular 199.

U.S. Department of the Interior.

1967. Special report, pesticide surveillance program, November 10, 1966. Bureau of Sport Fisheries and Wildlife. Oakland, CA.

U.S. Drug Enforcement Agency (DEA)

1985. Final environmental impact statement on the eradication of cannabis on federal lands in the continental United States. U. S. Department of Justice, Washington, DC.

U.S. Drug Enforcement Agency (DEA).

1986. Supplement to the draft environmental impact statement: cannabis eradication on non-Federal and Indian lands in the contiguous United States and Hawaii. U. S. Department of Justice, Washington, DC.

U.S. Endangered Species Act.

U.S. Environmental Protection Agency Regulations

U.S. Environmental Protection Agency (EPA).
Undated. Carbaryl Position Document No. 1. Office of Special PesticideReviews, Washington, DC.
U.S. Environmental Protection Agency (EPA).
1975. Initial scientific and minieconomic review of malathion. Wash., DC.
U.S. Environmental Protection Agency (EPA)
1980. Carbaryl decision document. Office of Pesticides and Toxic Substances, Washington, DC. (As cited in Dobroski, 1985.)
U.S. Environmental Protection Agency (EPA).
1982a. Acephate, tolerances. Federal Register 47(227):52994-5.
U.S. Environmental Protection Agency (EPA).
1982b. Guidance for the reregistration of manufacturing use and certain end use products containing methamidophos. September 1982.
U.S. Environmental Protection Agency (EPA).
1982c. Ecological effects topical discussion. Registration standard for methamidophos. Ecological Effects Branch, Hazard Evaluation Division. Washington, D.C. March 5, 1982.
U.S. Environmental Protection Agency (EPA)
1982d. Toxicology chapter of the methamidophos registration standard. March 1982.
U.S. Environmental Protection Agency (EPA)
1984. Guidance for the reregistration of pesticide products containing carbaryl as the active ingredient. Office of Pesticide Programs. Washington, DC.
U.S. Environmental Protection Agency (EPA)
1984a. Tox one-liner for carbaryl. Tox. Chem. No. 160. Washington, DC.
U.S. Environmental Protection Agency (EPA).
1984b. Guidance for the registration of pesticide products containing Carbaryl as the active ingredient. Office of Pesticide Programs, Washington, DC.
U.S. Environmental Protection Agency (EPA).
1984c. Acephate, EPA Tox one-liner. No. 2A. Washington, DC.
U.S. Environmental Protection Agency (EPA).
1984d. Addendum to science chapters prepared for the acephate reregistration standard. Ecological Effects Branch, Washington, DC.
U. S. Environmental Protection Agency (EPA).
1985. Guidance for the reregistration of pesticide products containing acephate as the active ingredient. Office of Pesticide Programs. Washington, D.C.
U.S. Environmental Protection Agency (EPA).
1985. Guidance for the reregistration of pesticide products containing acephate. Case #42. Washington, DC, September 1985.
U.S. Environmental Protection Agency, Office of Pesticide Programs, (EPA).
1986. Hazard Evaluation Division Standard Evaluation Procedure, Ecological Risk Assessment. EPA-540/9-85-001. Washington, DC.
U.S. Environmental Protection Agency (EPA).
1986a. Memorandum from William L. Burnam, Deputy Chief, Hazard Evaluation Division, to USDA, APHIS. September 4, 1986.

U.S. Environmental Protection Agency (EPA).

1986a. "Guidelines for the Health Risk Assessment of Chemical Mixtures." Federal Register 52(185):34014-340251. September 24, 1986.

U.S. Environmental Protection Agency (EPA).

1986a. Guidelines for the health risk assessment of chemical mixtures. Federal Register 52(185):43014-340251, Sept. 24, 1986.

U.S. Environmental Protection Agency (EPA).

1986b. Office of Pesticide Programs. Ecological Risk Assessment. Hazard Evaluation Division Standard Evaluation Procedure. EPA-540/9-85-001. Washington, DC.

U. S. Environmental Protection Agency (EPA).

1986b. June 9 letter to Guy Baier on the toxicity of BLM proposed formulations. Office of Pesticide Programs, Washington, DC.

U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office.

1986b. Health effects assessment for benzo(a)pyrene. Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Cincinnati, OH. NTIS PB No. 86 134335/AS.

U.S. Environmental Protection Agency (EPA).

1986c. Standard evaluation procedure: ecological risk assessment. Office of Pesticide Programs, Washington, DC.

U.S. Environmental Protection Agency (EPA).

1986c. Standard evaluation procedure: ecological risk assessment. Office of Pesticide Programs, Washington, DC.

U.S. Environmental Protection Agency, Environmental Criteria and Assessment Office.

1986c. Health effects assessment for benzene. Environmental Criteria and Assessment Office, U.S. Environmental Protection Agency, Cincinnati, OH. NTIS PB No. 86 134483/AS.

U.S. Environmental Protection Agency (EPA).

1986d. Draft guidance for the reregistration of pesticide products containing formaldehyde and paraformaldehyde. September 1986.

U.S. Environmental Protection Agency (EPA).

1987. Pesticide products; redesignation of formaldehyde and paraformaldehyde inert ingredients. Federal Register 52(2):321-322. January 5, 1987.

U.S. Environmental Protection Agency (EPA).

1987a. Malathion. Registration Standard. Office of Pesticides and Toxic Substances. Washington, D.C.

U.S. Environmental Protection Agency (EPA).

1987b. Guidance for the reregistration of pesticide products containing acephate as the active ingredient. Office of Pesticides and Toxic Substances, Washington, DC.

U.S. Environmental Protection Agency (EPA).

1988. Tox One-Liner for Carbaryl. Office of Pesticides and Toxic Substances, Washington, DC.

U.S. Environmental Protection Agency (EPA).

1988a. Acceptable Daily Intake (ADI) Tracking Report: Malathion. Office of Pesticides and Toxic Substances, Washington, DC.

U.S. Federal Insecticide, Fungicide, and Rodenticide Act.

U.S. Fish and Wildlife Service.

1986. Letter and attachments to APHIS concerning effect of Mormon cricket control on endangered wildlife species in Utah and Colorado. Galen L. Buterbaugh, Regional Director, Denver, CO.

U.S. Food and Drug Administration, Bureau of Foods.

1980. Methamidophos insecticide. Washington, DC.

U. S. Food and Drug Administration (FDA).

1980. Methamidophos-insecticide, SI class #. Bureau of Foods. Wash. D.C.

Van Overbeck, J. and R. Blondeau.

1954. Mode of action of phytotoxic oils. Weeds 3:55-65

Volk, W.A. and M.F. Wheeler.

1983. Basic Microbiology, 4th ed. J.B. Lippincott Company, Toronto, Ontario.

Volland, L.A. and J.D. Dell.

1981. Fire effects on Pacific Northwest forest and range vegetation. R6-RM-067 1981. Portland, OR. US Department of Agriculture, Forest Service, Pacific Northwest Region. 1-23.

Walker, W.W. and B.J. Stojanovic.

1973. Microbial versus chemical degradation of malathion in soil. Journal of Environmental Quality 2(2):229-232.

Walker, W.W.

1976. Chemical and microbiological degradation of malathion and parathion in an estuarine environment. Journal of Environmental Quality 5(2):210-216.

Waller, G.D.

1969. Susceptibility of an alfalfa leafcutting bee to residues of insecticides on foliage. Journal of Economic Entomology 62(1):189-92. (As cited in Dobroski, 1985.)

Wakeham, S.G. and R. Carpenter.

1976. Aliphatic hydrocarbons in sediments of Lake Washington. Limnology and Oceanography 21:711-723.

Warnock, R.E.

1972. Orthene leaching study--Environmental Protection Agency protocol. Chevron Chemical Co., Richmond, CA (As cited in U.S. Environmental Protection Agency, 1982.)

Washington State Department of Fish and Wildlife

Memorandum of Understanding, Management Strategies and Common Goals.

Washington State Department of Game

Memorandum of Understanding, Management Strategies and Common Goals.

Washington State Department of Social and Health Services.

1986. Report: Vital Statistics and Induced Terminations of Pregnancy 1985. State of Washington, Division of Public Health. Olympia, WA.

Washington State Forest Practices Act.

Watersheds - Formal Agreements with Ashland, Medford, Portland, and The Dalles, OR; and Seattle, WA.

Weber, J. B., P. J. Shea, and H. J. Strek.

1980, An Evaluation of Nonpoint Sources of Pesticide Pollution in Runoff. In Environmental Impact of Nonpoint Source Pollution, M. R. Overcash and J. M. Davidson (Eds.) Ann Arbor Science Pub. Inc., pp. 69-98.

Weber-Tschopp, A., T. Fisher, and E. Grandjean.

1977. Irritating effects of formaldehyde on men (Ger.). International Archives of Occupational and Environmental Health 39:207-218. (As cited in IARC, 1982)

Weil, C.A., M.D. Woodside, C.P. Carpenter, and H.P. Smyth, Jr.

1972. Current status of tests of carbaryl for reproductive and teratogeniceffect. Toxicology and Applied Pharmacology 14:409-419.

Weil, C.S., M.D. Woodside, B. Bernard, N.L. Conara, and C.P. Carpenter.

1973. Comparative effect of carbaryl on rat reproduction and guinea pig teratology when fed either in the diet or by stomach intubation. Toxicology and Applied Pharmacology 26:621-638.

Weininger, R. B., G. Davis, and C. D. Hawks.

1987. Herbicides and cancer. JAMA 257(17):2292.

West, Neil E.

1969. Successional changes in the montane forest of the central Oregon Cascades. The Am. Midland Naturalist. 81(1):265-271.

Wickman, B.E.

1978. A case study of a Douglas-fir tussock moth outbreak and stand conditions ten years later. USDA Forest Service, Pacific Northwest Forest and Range Exp. Sta. Res. Pap. PNW-244., 22 p.

Wiggins, O.G., M.H.J. Weiden, and C.S. Weil.

1970. Sevin carbaryl insecticide-plant metabolites and their mammalian toxicity. Paper presented at the VII International Congress of Plant Protection, Paris, September 1970. (As cited in Dobroski, 1985.)

Willcox, H.H. III.

1972. Progress Report of December 7. Environmental impact study of aerially applied Sevin 4-Oil on a forest and aquatic ecosystem. Lake Ontario Environmental Laboratory, Oswego, NY. Unpublished.

Williams, C.

1967. Spruce budworm damage symptoms related to radial growth of grand fir, Douglas-fir and Engelmann spruce. For. Sci. 13:274-285.

Williams, J. R., A. D. Nicks, and J. G. Arnold.

1985. Simulator for water resources in rural basins, Journal of Hydraulic Engineering, 3(6):970-986.

Wills, J.H., E. Janeson, and F. Coulston.

1968. The effects of oral doses of carbaryl on man. Clinical Toxicology I (3):265-271.

Wilson, W. T.

1962. J. Insect Pathology. 4:269-270.

Wischmeier, W.H. and D.D. Smith.

1978. Predicting Rainfall Erosion Losses--A Guide to Conservation Planning. U.S. Department of Agriculture. Government Printing Office, Washington, DC. Agriculture Handbook No. 537. 58 pp.

Wolfe, N.L., R.G. Zepp, J.A. Gordon, G.L. Baughman, and D.M. Cline.

1977. Kinetics of chemical degradation of malathion in water. Environmental Science and Technology 11(1):88-93.

Wolfe, N.L., R.G. Zep, and D.F. Pacis.

1978. Carbaryl, propham, and chloropropham: a comparison of the rates of hydrolysis and photolysis with the rate of biolysis. Water Resources 12:565-571.

Wolfsdorf, J. and D. Paed.

1976. Kerosene intoxication: an experimental approach to the etiology of the CNS manifestation in primates. J. Pediatr. 88(6):1037-1040.

Wulf, N. William and Rex G. Cates.

1985. Site and stand characteristics. In: Martha H. Brookes; Robert W. Campbell; J.J. Colbert; Russel G. Mitchell; R.W. Stark, eds. Western spruce budworm Tech. Bull. 1694. Washington, D.C. U.S. Department of Agriculture, Forest Service. Canada-United States Spruce Budworms Program. Chapter 5.

Yates, W. E., N. B. Akesson, and R. E. Cowden.

1978. Atmospheric transport of sprays from helicopter applications in mountainous terrain. ASAE paper No. 78-1504.

Yates, W. E., N. B. Akesson, and R. E. Cowden.

1984. Measurement of drop size frequency from nozzles used for aerial applications of pesticides in forests. USDA Forest Service, Washington, DC.

Zinkl, J.G., C.J. Henny, and L.R. DeWeese

1977. Brain cholinesterase activities of birds from forests sprayed with trichlorfon (Dylox) and carbaryl (Sevin-4-Oil). Bulletin of Environmental Contamination and Toxicology 17:379-86. (As cited in Dobroski, 1985.)

Zinkl, J.G., R.B. Roberts, C.J. Henny, and D.J. Lenhart.

1980. Inhibition of brain cholinesterase activity in forest birds and squirrels exposed to aerially applied acephate. Bulletin of Environmental Contamination and Toxicology 24:676-683. (As cited in Lambert, 1985.)

Zinkl, J.G., R.B. Roberts, P.J. Shea, and J. Lasmanis.

1981. Toxicity of acephate and methamidophos to dark-eyed juncos. Archives of Environmental Contamination and Toxicology 10:185-192. (As cited in Lambert, 1985.)

O: Glossary

APPENDIX O

Glossary

A

ACEPHATE
Organophosphate insecticide; the active ingredient found in insecticide formulations sold under the trade name, Orthene.

ACETYLCHOLINESTERASE
An enzyme released at nerve endings in order to accelerate hydrolysis of acetylocholine, thereby ending nerve stimulation after an impulse has passed.

ACTINEDID MITE
Mites belonging to the family Actinedidae; usually represented by species living in soil and leaf litter.

ACTIVE INGREDIENT (AI)
The effective part of a pesticide formulation, or the actual amount of the technical material present in the formulation.

ACUTE TOXICITY
The toxicity of a compound when given in a single dose, or in multiple doses, over a period of 24 hours or less.

ADVERSE
Any action which is antagonistic or opposite to the preferred action.

ALLUVIUM
A general term for all material deposited by streams.

ALTERNATIVE
One of several policies, plans, or projects proposed for decisionmaking.

ANADROMOUS FISH
Those species of fish, spawned in fresh water, which mature in the sea, and migrate back into fresh water streams to spawn. Salmon, steelhead, and shad are examples.

ANALYSIS UNIT
A specific parcel of land considered as a single unit for treatment of spruce budworm infestation.

ANIMAL UNIT
Considered to be one mature (1,000 lb) cow, or the equivalent, based upon average daily forage consumption of 26 lbs dry matter per day.

ANIMAL UNIT MONTH (AUM)
The forage requirement for 1 month for a 1,000-lb mature animal (cow), or its equivalent, based upon average daily forage consumption of 26 lbs dry matter per day.

ARTHROPODS
Major group of invertebrate animals belonging to the phylum Arthropoda. This group includes insects, spiders, and crustaceans.

AVAILABLE
Land which has not been administratively or legislatively withdrawn from timber production.

AVIAN
Pertaining to birds.

B

BACILLUS THURINGIENSIS (*B.T.*)
Scientific name of the active ingredient of a bacterial insecticide which is a formulation of spores and unique crystalline bodies produced by the bacterium. The active ingredient in biological insecticides sold under such names as DipelR, BactospeineR and ThuricideR. It acts as a stomach poison to leaf-eating lepidopterous insects (moths and butterflies) as the crystal dissolves and paralyzes the gut wall, causing the larvae to stop feeding.

BACKGROUND
The visible terrain beyond the foreground and middleground where individual trees are not visible but are blended into the total fabric of the forest stand (see Foreground and Middleground).

BENEFIT
(Value) Inclusive term used to quantify the results of a proposed activity, program, or project, expressed in monetary or nonmonetary terms.

BENEFIT-COST RATIO
(Cost efficient) Measure of economic efficiency, computed by dividing total discounted benefits by total discounted costs.

BIOACCUMULATION
The uptake and temporary storage of a chemical in animal flesh and organs. Over a period of time, a higher concentration of chemical may be found in the organism than in the environment.

BOVINE
Referring to cattle.

BRACONID
Members of the wasp family Braconidae - small, usually parasitoid wasps that are largely beneficial to man.

B.T.
Abbreviation for *Bacillus thuringiensis*.

BUFFER ZONES OR AREAS
Usually set around sensitive areas such as lakes, streams, or ponds that are not directly treated with insecticides; or areas set around the same, including people who object to chemical insecticides, that are treated instead with microbial insecticides such as B. t. In some cases, may refer to areas actually treated, such as treatment of buffer zones along roads.

C

CADDISFLY
A small moth-like insect. The larvae live in fresh water in portable cases they construct around themselves. Member of order Trichoptera.

CANOPY
The uppermost spreading, branchy layer of a forest.

CARBAMATE
A salt or ester of carbamic acid.

CARBARYL
Carbamate insecticide; the active ingredient in insecticide formulations sold under the trade name SevinR. Carbaryl expresses contact and stomach poison action on target insects and shows relatively long residual effects.

CARCINOGENICITY
Tendency of a substance to cause cancer.

CEQ
Council on Environmental Quality.

CHITIN
A semi-transparent horny substance forming the principal component of crustacean shells, insect exoskeletons, and the cell walls of certain fungi.

CHITINASE
An enzyme that hydrolyzes chitin.

CHOLINESTERASE
See acetylcholinesterase.

CHORISTONEURA OCCIDENTALIS
Scientific name of the western spruce budworm.

CHRONIC HEALTH EFFECTS
Health effects that may take repeated exposures over a period of months or years before becoming apparent. Chronic health effects may blend into the general health problems of life and never be detected.

CHRONIC TOXICITY
The effect of a compound on test animals when exposed to sublethal amounts continually. Usually, daily exposures over a period of time: weeks, months, or years.

CLASS I STREAM
Perennial or intermittent streams (or segments thereof) that are direct sources of water for domestic use, or are used by large numbers of fish for spawning, rearing, or migration, or flow enough water to be a Class I stream.

CLASS II STREAM
Perennial or intermittent streams (or segments thereof) that are used by moderate, though significant, numbers of fish for spawning, rearing, or migration, have a moderate influence on a Class I stream, or are a major contribution to a Class II stream.

CLASS III STREAM
All other perennial streams or segments thereof not meeting higher class criteria.

CLASS IV STREAM
All other intermittent streams not meeting higher class criteria.

CLEARCUTTING
Removal of virtually all trees, large or small, in a timber stand in one cutting operation. Leads to the establishment of an even-aged stand.

CLIMAX
The culminating stage in plant succession for a given site where the vegetation has reached a highly stable condition.

CLIMAX SPECIES
Those species that dominate the forest stand in either numbers per unit area or biomass at climax.

CODE OF FEDERAL REGULATIONS (CFR)
The listing of various regulations pertaining to management and administration of National Forests.

COMMERCIAL FOREST LAND
Forest land tentatively suitable for the production of continuous crops of timber and that has not been withdrawn.

COMMERCIAL THINNING
Any type of thinning of trees producing merchantable material at least equal to the value of the direct costs of timber harvesting.

COMMODITY
A transportable resource product with commercial value; all resource products which are articles of commerce.

COMPACTION
The packing together of soil particles by forces exerted at the soil surface.

CONCERN
A point matter, or question raised by management, that must be addressed in the planning process.

CONFLAGRATION
A large and destructive fire (see Wildfire).

CONSENSUS
A process in which a mutually agreeable opinion is reached by a variety of individuals concerning an issue.

COST EFFICIENCY
The usefulness of specified inputs (costs) to produce specified outputs (benefits). In measuring cost efficiency, some outputs, including environmental, economic, or social impacts, are not assigned monetary values but are achieved at specified levels in the least cost manner. Cost efficiency is usually measured using present net value, although use of benefit-cost ratios and rates of return may be appropriate. (36 CFR 219.3)

COVER
Vegetation used by wildlife for protection from predators, to ameliorate conditions of weather, or in which to reproduce. See Hiding Cover; Thermal Cover.

CRITICAL HABITAT
For threatened or endangered species, the specific areas within the geographical area occupied by the species (at the time it is listed, in accordance with provisions of Section 4 of the Endangered Species Act) on which are found those physical or biological features essential to the conservation of the species. This habitat may require special management considerations or protection. Protection may also be required for additional habitat areas outside the geographical area occupied by the species at the time it is listed, based upon a determination of the Secretary of the Interior that such areas are essential for the conservation of the species.

CULMINATION OF MEAN ANNUAL INCREMENT
(CMAI) The age at which the annual increment of growth of a timber stand reaches its maximum.

CULTURAL RESOURCES
Buildings, sites, areas, architecture, memorials, and objects having scientific, prehistoric, historic, or social values.

CUMULATIVE EFFECTS
The combined effects of two or more management activities. The effects may be related to the number of individual activities, or to the number of repeated activities on the same piece of ground. Cumulative impacts can result from individually minor, but collectively significant, actions taking place over a period of time.

CURRENT DIRECTION
The existing direction in approved management plans; continuation of existing policies; standards and guidelines; current budget updated for changing costs over time; and, to the extent possible, production of current levels and mixes of resource outputs.

D

DBH
See Diameter at Breast Height

DECISION NOTICE
A document which announces the decision and resulting actions for a Federal project.

DEFOLIATION
A process in which all leaves are removed from a tree.

DEGRADATION
The breakdown of a chemical compound into simple components. Related to the persistence of the chemical in terms of ability to kill insects or to produce health effects.

DEIS
Draft Environmental Impact Statement

DERMAL
Of the skin.

DEVELOPED RECREATION
Outdoor recreation requiring significant capital investment in facilities to handle a concentration of visitors on a relatively small area. Examples are ski areas, resorts, and campgrounds.

DIAMETER AT BREAST HEIGHT (DBH)
The diameter of a tree 4.5 feet above average ground level, except that in National Forest practice it is measured from the highest ground level. Abbreviated dbh. The additional abbreviations, ob and ib, are used to designate whether the diameter refers to the measurement outside or in the bark.

DIPEL (R)
Trade name of biological insecticide formulations containing the bacterium Bacillus thuringiensis.

DISPERSED RECREATION
Outdoor recreation in which visitors are diffused over relatively large areas. Where facilities or developments are provided, they are more for access and protection of the environment than for the comfort or convenience of the people.

DIVERSITY
The distribution and abundance of different plant and animal communities and species within the area covered by a land and resource management plan.

DOMESTIC WATERSHED
Any recognized watershed serving less than 25 individuals or for less than 60 days per year.

DRIFT
The movement of air-borne particles from the intended contact area to other areas.

E

EC50
Median effective concentration; concentration (ppm or ppb) of the toxicant in the environment (usually water) which produces a designated effect to 50 percent of the test organisms exposed.

ECOLOGICAL DIVERSITY
The numbers and types of ecological communities contained within a specified area.

ECOLOGICAL PROCESSES
The interaction of environmental systems in promoting change in the environment.

ECOSYSTEM
An interacting system of organisms considered together with their environment; e.g., marsh, watershed, and lake ecosystems.

EDGE
The boundary between two or more elements of the environment; e.g., field and woodland.

EFFECTS
Environmental consequences as a result of a proposed action. Included are direct effects, which are caused by the action and occur at the same time and place, and indirect effects, which are caused by the action and are later in time or further removed in distance, but which are still reasonably foreseeable. Indirect effects may include population growth-inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

The terms "Effects" and "Impacts" as used in this statement are synonymous. Effects may be ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic quality, historic, cultural, economic, social, or health-related; whether direct, indirect, or cumulative. Effects resulting from actions may have both beneficial and detrimental aspects (40 CFR 1508.8).

EFFICIENCY, COST
The usefulness of specified inputs (costs) to produce specified outputs (benefits). In measuring cost efficiency, some outputs (such as environmental, economic, or social impacts) are not assigned monetary values but are achieved at specified levels in the least-cost manner. Cost efficiency is usually measured using present net value, although use of benefit-cost ratios and rates-of-return may sometimes be appropriate.

EFFICIENCY, ECONOMIC
The usefulness of inputs (costs) to produce outputs (benefits) and effects when all costs and benefits that can be identified and valued are included in the computations. Economic efficiency is usually measured using present net value, although use of benefit-cost ratios and rates-of-return may sometimes be appropriate.

EIS
Environmental Impact Statement

ENDANGERED SPECIES
Any species of animal or plant which is in danger of extinction throughout all or a significant portion of its range. Not included are members of the class, Insecta, which have been determined by the Secretary of Interior to constitute a pest whose protection under the provisions of this Act (Endangered Species Act of 1973) would present an overwhelming and overriding risk to man. An endangered species must be designated in the Federal Register by the appropriate Federal Agency Secretary.

ENDEMIC
Restricted to and constantly present in a particular locality.

ENDOTOXIN
A toxic substance found in certain disease-producing bacteria and liberated by the disintegration of the bacterial cell: They harm certain tissue cells.

ENVIRONMENT
The aggregate of physical, biological, economic, and social factors affecting all organisms in an area.

ENVIRONMENTAL ANALYSIS
Procedure defined by the National Environmental Policy Act of 1969 whereby the environmental impacts of a planned action are objectively reviewed.

ENVIRONMENTAL ASSESSMENT
A concise public document which provides sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement or Finding of No Significant Impact. It aids in compliance with the NEPA when no Environmental Impact Statement is needed.

ENVIRONMENTAL IMPACT STATEMENT
A document prepared by a Federal Agency in which anticipated environmental effects of a planned course of action or development are evaluated.

ENVIRONMENTAL PROTECTION AGENCY (EPA)
The Federal Agency with primary responsibility for enforcement of environmental regulations.

EPA
Environmental Protection Agency.

EPIDEMIC
Prevalent and spreading rapidly; widespread.

EPIDEMIOLOGY
Originally, the science that studied the cause and control of epidemics of communicable diseases in a region. Now, its subject matter includes diseases caused by chemicals and other environmental factors.

ERODIBLE
Susceptible to erosion.

EROSION
The wearing away or detachment of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitation creep.

EVEN-AGE MANAGEMENT
The application of a combination of actions that results in the creation of stands in which trees of essentially the same age grow together. Managed even-aged forests are characterized by a distribution of stands of varying ages (and therefore tree sizes) throughout the forest area. The difference in age between trees forming the main canopy level of a stand usually does not exceed 20 percent of the age of the stand at harvest rotation age. Regeneration in a particular stand is obtained during a short period at or near the time the stand has reached the desired age or size for regeneration and is harvested. Clearcut, shelterwood, or seed tree cutting methods produce even-aged stands.

EXPOSURE
The pathways of human exposure to chemicals are dermal, oral, and inhalation.

EXPOSURE ASSESSMENT
Determines the level of exposure for a given agency policy or activity.

F

FEIS
Final Environmental Impact Statement

FETOTOXICITY
The ability to produce toxic effects in a fetus of humans or animals.

FORAGE
Food for animals.

FOREGROUND
A term used in visual (scenery) management to describe the stand of trees immediately adjacent to a high-value scenic area, recreation facility, or forest highway (see "Background", "Middleground").

FOREST CANOPY
The crown cover or upper foliage of forest trees.

FOREST LAND
Land at least 10 percent occupied by forest trees of any size, or formerly having had such tree cover, and not currently developed for nonforest use.

FORMULATION
The form in which a pesticide is packaged or prepared for use.

FRY
Juvenile fish up to the time when the yolk sac has been absorbed.

FUEL
Living or dead plant material that will burn.

FUEL LOADING
The amount of fuel present, expressed quantitatively as weight of fuel per unit area, generally expressed in tons per acre.

FUELS
Any material that will carry and sustain a forest fire, primarily natural materials, both live and dead.

G

GALL MOTHS
Moths characterized by larvae that feed in the interior of plants producing galls (abnormal growths of plant tissue) in which pupation takes place.

GAMASID MITES
Usually predaceous mites of soil and leaf litter.

GAME
Wildlife that are hunted for sport and regulated by State game regulations.

GAVAGE
(Used in testing) Forced feeding, especially through a tube passed into the stomach.

GENERIC ASSEMBLAGES
Groupings of species of a common genera.

GOODS AND SERVICES
The various outputs, including on-site uses, produced from forest and rangeland resources.

GUIDELINE
An indication or outline of policy or conduct.

H

HABITAT
The place where a plant or animal naturally or normally lives and grows.

HALF-LIFE
The time required for half the amount of substance (such as an insecticide) in, or introduced into a living system, to be eliminated whether by excretion, metabolic decomposition, or other natural process.

HERBIVORES
Animals that feed on plants.

HIDING COVER
Vegetation that provides a screening for wildlife from predators. Usually used in conjunction with big-game habitat requirements.

HYMENOPTERA
A large order of insects comprised of ants, bees, sawflies, and wasps. The typical adult has four membranous wings and chewing type mouthparts.

I

ICHEUMONID WASP
Large varied family of wasps, many of which are parasitic, generally considered beneficial as pest parasitoids or predators.

IMPACT, ECONOMIC
The change, positive or negative, in economic conditions, including distribution and stability of employment and income in affected local, regional, and national economies, which directly or indirectly results from an activity, project, or program.

INERT INGREDIENT
An ingredient found in a pesticide formulation in addition to the active ingredients which provides a carrier medium and improves the efficacy of the active ingredient.

INHERENT
Those factors that exist in something as a permanent element.

INSECT DRIFT
Movement of dead or dying aquatic insects within a stream; an occurrence of natural mortality that can be dramatically increased with introduction of toxic substances into a stream.

INSECTIVOROUS
Feeding chiefly on insects.

INSTAR
The term for a insect before each of the molts (shedding of its skin) it must go through in order to increase in size. Upon hatching from its egg, the insect is in instar I and is so called until it molts, when it begins instar II, etc.

INTEGRATED PEST MANAGEMENT (IPM)
A process for selecting strategies to regulate forest pests in which all aspects of a pest-host system are studied and weighed. The information considered in selecting appropriate strategies includes the impact of the unregulated pest population on various resource values and alternative regulatory tactics and strategies. Benefit and cost estimates for these alternative-sound silvicultural practices and ecology of the pest-host system are also considerations in development of the management strategy. This strategy consists of a combination of tactics; for example timber stand improvement plus selective use of pesticides. A basic principle in the choice of strategy is that it be ecologically compatible or acceptable.

INTERACTIONS
Mixtures of chemicals may have substantially different toxicity than the sum of the toxicities of the components. The chemicals may interact to increase toxicity (synergism) or to decrease toxicity (antagonism).

INTERDISCIPLINARY TEAM
A team of people that collectively represent several disciplines and whose duty it is to coordinate and integrate the planning activities.

INVERTEBRATE
Major group of animals, of which arthropods are members, characterized by the lack of backbone and spinal column.

IRRETRIEVABLE
Applies to losses of production, harvest, or use of renewable natural resources. For example, some or all of the timber production from an area is irretrievably lost during the time an area is used as a winter sports site. If the use is changed, timber production can be resumed. The production lost is irretrievable, but the action is not irreversible.

IRREVERSIBLE
Applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors such as soil productivity, that are renewable only over long time periods. Irreversible also includes loss of future options.

ISSUE
A point, matter, or question of public discussion or interest to be addressed or decided through the planning process.

L

LAND MANAGEMENT PLANNING
The process of organizing the development and use of lands and their resources in a manner that will best meet the needs of people over time, while maintaining flexibility for a combination of resources for the future.

LARVA (PLURAL LARVAE)
An insect in the earliest stage of development after it has hatched and before it changes into pupa; a caterpillar, maggot, or grub.

LC50
Median lethal dose; the size of a single dose of a chemical necessary to kill 50 percent of the organisms in a specific test situation. It is usually expressed in the weight of the chemical per unit of body weight (mg/kg). It may be fed (oral LD50), applied to the skin (dermal LD50), or administered in the form of vapors (inhalation LD50).

LD50
Median lethal dose; is the milligram of toxicant per kilogram of body weight (mg/kg) lethal to 50 percent of

the test animals to which it is administered under the conditions of the experiment.

LEPIDOPTERA
A large order of insects, including butterflies and moths; characterized by four scale-covered wings and coiled sucking mouthparts.

LOAEL (Lowest Observable Adverse Effect Level)
The lowest dose at which toxic effects can be observed in the test organism. Used in the chronic toxicity assessment.

M

MAINTENANCE
A strategy used in the alternatives requiring relative small doses of energy and resources to perpetuate a stable condition.

MANAGEMENT CONCERN
Any factor which is viewed as being detrimental by management.

MANAGEMENT DIRECTION
A statement that includes: multiple use and other goals and objectives, the associated management strategies, and standards and guidelines for attaining them.

MANAGEMENT PRACTICE
A specific action, measure, course of action, or treatment.

MANAGEMENT STANDARDS
A unit of measure used to assess the implementation of a management practice or requirement.

MANAGEMENT STRATEGY
Management practices and intensity selected and scheduled for application on a management area to attain multiple use and other goals and objectives.

MARGIN OF SAFETY (MOS)
An arbitrarily established separation between the no-effect level of chemicals found in animal experiments and the level of exposure estimated to be safe for humans. This is used in estimating an Allowable Daily Intake (ADI) by the EPA (Environmental Protection Agency) and FDA (Food and Drug Administration) for tolerances of residues in food and water. A common convention for chemicals is to use a MOS of 100 which means the "safe" level for humans is 100 times less than the no-effect level established in animal experiments.

MASTITIS
Inflammation of the breast or mammary gland.

MATURE TIMBER
Trees that have attained full development, particularly in height, and are in full seed production.

MBF
Thousand board feet.

METABOLITES
Products of the chemical changes in living cells that provide energy and assimilate new material.

MEXACARBATE
A carbamate insecticide.

MG/KG
Milligrams per kilogram; used to designate the amount of toxicant required per kilogram of body weight of test organisms to produce a designated effect; usually the amount necessary to kill 50 percent of the test animals. One mg/kg = 1 ppm, 1 mg = 0.000035 ounce, and 1 kg = 2.2 lbs.

MG/KG/DAY
Milligrams per kilogram of body weight per day.

MICROBIAL DEGRADATION
The breakdown of a chemical substance into simpler components by bacteria.

MICROORGANISM
A living organism so small it can be seen only with a microscope.

MIDDLEGROUND
The visible terrain beyond the foreground where individual trees are still visible but do not stand out distinctly from the stand.

MINORITY
Persons as specified in Directive 15, Office of Federal Statistical Policy and Standards, U.S. Department of Commerce, Statistical Policy Handbook (1978). Generally identified as one of the following four categories: Alaskan Native or American Indian, Asian or Pacific Islander, Black, Hispanic.

MITIGATION
Actions to avoid, minimize, reduce, eliminate, or rectify the impact of a management practice.

MMBF
Million board feet.

MODIFICATION
A visual quality objective meaning human activity may dominate the characteristic landscape but must, at the same time, utilize natural established form, line, color, and texture. It should appear as a natural occurrence when viewed in foreground or middleground.

MONITORING
A process to collect significant data from defined sources to identify departures or deviations from expected plan outputs.

MUNICIPAL WATERSHED
One that serves a public water system as defined in Public Law 93-523 (Safe Drinking Water Act) and associated regulations. Water for human consumption is provided for at least 25 individuals for at least 60 days per year. Forest

Service management could have a significant effect on the quality of water at the intake point.

MUTAGENICITY
The capacity of a substance to cause changes in genetic material.

N

1-NAPTHYL CARBAMATE
A chemical substance derived from the natural breakdown of carbaryl and 1-napthol.

NATIONAL ENVIRONMENTAL POLICY ACT (NEPA 1969)
An Act to declare a national policy which will encourage productive and enjoyable harmony between humans and their environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of humans; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality.

NEEDLE MINER
Any insect, usually larval moths, that burrows and feeds on the interior portions of the needles of evergreen trees.

NEPA
National Environmental Policy Act of 1969, Public Law 91-190.

NEPA PROCESS
A process, mandated by NEPA, which concentrates decisionmaking around issues, concerns, alternatives, and the effects of alternatives on the environment.

NFMA
The National Forest Management Act of 1976.

NICHE
A habitat suitable for a particular organism and to which that organism is usually adapted.

NO ACTION
See Current Direction. Also one of four strategies used in the alternatives. No action means no interference with natural process by humans.

NOEL
No Observable Effect Level. In a series of dose levels tested, the highest level at which no effect is observed, i.e., safe in the species tested.

NONTARGET ORGANISMS
Those organisms that inhabit the treatment area in addition to the pest species being treated. These organisms could be affected by the insecticide or treatment project.

NOXIOUS WEEDS
Species of plants that cause disease or are injurious to crops, livestock, or land.

O

OBJECTIVE
A concise, time-specific statement of measurable planned results that respond to pre established goals. An objective forms the basis for further planning to define the precise steps to be taken and the resources to be used in achieving identified goals (36 CFR 219.3).

OLD GROWTH
An old-growth stand is defined as any stand of trees 10 acres or greater generally containing the following characteristics: 1) stands contain mature and overmature trees in the overstory and are well into the mature growth stage; 2) stands will usually contain a multi-layered canopy and trees of several age classes; 3) standing dead trees and down material are present; and 4) evidence of human activity may be present; but does not significantly alter the other characteristics and would be a subordinate factor in a description of such a stand.

OLD-GROWTH STAND
See Old Growth

ORBATID MITES
Usually scavenger mites of soil and leaf litter. They are important in promoting soil fertility through the breakdown of organic matter.

ORTHENE (R)
Commercially produced chemical insecticide formulation containing the active ingredient, acephate.

OVERSTORY
The portion of trees in a forest which forms the uppermost layer of foliage.

P

PACIFIC NORTHWEST REGION
Includes the States or Oregon and Washington, portions of two Counties in California, and parts of three Counties in Idaho. The Region (sometimes called "Region 6") contains 19 National Forests and 1 National Grassland.

PARASITE
An animal that lives in or on the body of another living animal (its host), at least during part of its life cycle, feeding on the tissues of its host. Most insect parasites of other insects kill their host.

PATHOGEN
Any microorganism that can cause disease.

PERMITTEE
Holder of a permit to use National Forest land for a specific purpose.

PHEROMONE
Chemical produced and emitted by female moths to attract male moths for mating.

PHYTOPHAGOUS
Referring to plant-eating; herbivorous.

PIONEER SPECIES
A plant capable of invading bare sites (e.g., a newly exposed soil surface) and persisting there, i.e., "colonizing" them, until supplanted.

PLANT COMMUNITIES
A vegetation complex, unique in its combination of plants, which occurs in particular locations under particular influences. A plant community is a reflection of integrated environmental influences on the site; i.e., soils, temperature, elevation, solar radiation, slope, aspect, and rainfall.

PLECOPTERA
Stoneflies. Group of insects, the nymphs of which are aquatic and mostly phytophagous.

POLICY
A guiding principle upon which a specific decision or set of decisions is based.

POPULATION DYNAMICS
The study of changes and the reasons for changes in population size.

PPB
Parts per billion; the number of parts of a substance in question per billion parts of a given material. One ppb = 1 ug/liter (water or air).

PPM
Parts per million; the number of parts of a substance in question per million parts of a given material. (1 ounce of salt in 62,500 lbs of sugar). One ppm = 1 mg/kg (on a weight basis) = 1 mg/liter (water or air).

PRECOMMERCIAL THINNING
Any type of thinning that takes place in a stand of trees before the size or condition of the material cut or killed makes it of sufficient value to meet the costs of the activity.

PREDATOR
An animal that preys on others.

PRESCRIPTION (SILVICULTURAL)
The formal written plan of action to carry out a silvicultural treatment of a forest stand to achieve specific objectives.

PRESENT NET VALUE
The difference between the discounted values (benefits) of all outputs to which monetary values or established market prices are assigned, and the total discounted costs of managing the planning area (36 CFR 219.3).

PRESERVATION (VISUAL)
See Visual Quality Objective.

PROBABILITY
A number expressing the likelihood of occurrence of a specific event, such as the ratio of the number of experimental results that would produce the event to the total number of events considered possible.

PROGRAMMED HARVEST
Timber scheduled for harvest for a specific year.

PUBLIC ISSUE
A subject or question of widespread public interest relating to management of the National Forest System (36 CFR 219.3).

PUPA (PLURAL PUPAE)
The immobile, transformation stage in the development of an insect that, as an adult, is completely different in its appearance compared to what it looked like when it hatched from its egg. Examples include beetles, flies, moths, and wasps.

R

RAPTORS
Birds of prey including hawks, eagles, falcons, and owls.

RECREATION OPPORTUNITY
An opportunity for a user to participate in a preferred activity within a preferred setting in order to realize those satisfying experiences which are desired.

REFORESTATION
The natural or artificial restocking of an area with forest trees; most commonly used in reference to artificial restocking.

REGENERATION
The renewal of a tree crop, whether by natural or artificial means. Also the young tree crop itself.

REHABILITATION
A short-term management alternative used to return existing visual impacts in the natural landscape to a desired visual quality.

REINVASION
The movement of an organism from adjacent populations back into an area where the organism has been excluded.

RESEARCH NATURAL AREA
An area, typifying an important forest, shrubland, grassland, alpine, aquatic or geologic type, or other natural situation that has special or unique characteristics which is set aside to provide a benchmark for education and research.

RESIDUAL
Refers to remaining.

RESURGENCE
The growth of a population back to pre-treatment levels from a resident population.

RIPARIAN HABITAT
That portion of a watershed or shoreline influenced by surface or subsurface waters, including stream or lake margins, marshes, drainage courses, springs, and seeps.

RIPARIAN VEGETATION
Nonaquatic vegetation found within riparian areas. Typically, this vegetation is dependent upon a seasonally high water table.

RIPARIAN ZONES
The transitional zone located between the terrestrial and aquatic zones. This stream-adjacent area contains plants, animals, and soil types specific to this area.

RISK
The degree and probability of loss based upon chance.

RISK ASSESSMENT
An analytic process that is firmly based on scientific considerations, but also requires judgments to be made when the available information is incomplete. These judgments inevitably draw on both scientific and policy considerations.

S

SAFETY FACTOR
A factor conventionally used to extrapolate human tolerances for chemical agents from "No Observed Effect Levels" in animal test data.

SALMONOID FISH
Fish having salmon-like characteristics - includes the trouts, salmons, and whitefish.

SCENIC AREAS
Places of outstanding or matchless beauty which require special management to preserve these qualities. They may be established under 36 CFR 294.1 whenever lands possessing outstanding or unique natural beauty warrant this classification.

SCOPING
An integral part of environmental analysis. Scoping entails: Examining a proposed action and its possible effects; establishing the depth of environmental analysis needed; and determining analysis procedures, data needs, and task assignments.

SCOPING PROCESS
A process in conjunction with environmental analysis which identifies issues and concerns that are within the authority of the Forest Service to resolve.

SCOPING SESSION OR ACTIVITIES
As defined under the National Environmental Policy Act - an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action. This may include public meetings whereby significant issues are identified, or may simply be letters of inquiry to interested agencies, groups, or individuals.

SECOND GROWTH
Forest growth that has come up naturally after some drastic interference with the previous forest growth; e.g., cutting, serious fire, or insect attack.

SENSITIVE SPECIES
Those species of plants or animals that have appeared in the Federal Register as proposed for classification and are under consideration for official listing as endangered or threatened species, that are on an official State list, or that are recognized by the Regional Forester as needing special management to prevent their being placed on Federal or State lists.

SERAL
A biotic community which is a developmental, transitory stage in an ecologic succession.

SEVIN 4-OIL (R)
Commercial insecticide formulation containing the active ingredient carbaryl.

SEVIN 80 S (R), SEVIN SPRAYABLE (R), SEVIN XLR (R)
See Sevin 4-Oil.

SITE PRODUCTIVITY
Production capability of specific areas of land to produce defined outputs such as AUMs, cubic feet/acre/year, etc.

SLASH
The wood residue left on the ground after timber cutting and/or accumulating there as a result of storm, fire, or other damage. It includes unused logs, uprooted stumps, broken or uprooted stems, branches, twigs, leaves, bark, and chips.

SLOPE
An inclined ground surface in which the inclination is expressed as a ratio of horizontal to vertical distance. The face of an embankment or cut section.

SNAG
A standing dead tree.

SOCIOECONOMIC
Pertaining to, or signifying the combination or interaction of, social and economic factors.

SOIL
The unconsolidated mineral and organic material on the immediate surface of the earth.

SOIL RESOURCE
A product of the interaction of parent materials, vegetation, climate, and relief over time; it is a nonrenewable resource.

SPORE
Any small cell that can regenerate into a new individual.

SPREADER/STICKER AGENT
Substances that are added to the spray tank, separate from the pesticide formulation, that improve the performance of the pesticide. Spreader causes the formulation to spread out more to increase coverage; sticker increases the adhesion or "stickiness" of the pesticide.

STAND
Timber possessing uniformity to type, age class, risk class, vigor, size class, and stocking class.

STANDARD
A principle requiring a specific level of attainment; a rule against which to measure.

STOCKING LEVEL
A measure of the existing number of trees in a stand in relation to the number desired for optimum growth and volume.

STRATEGY
A carefully planned course of action. In this EIS, four strategies are incorporated into the alternatives presented, no action, prevention, correction, and maintenance.

SUBACUTE
The effects observed from doses of intermediate duration, usually three months.

SUCCESSIONAL STAGE
A stage or recognizable condition of a plant community which occurs during its development from bare ground to climax.

SUITABILITY
The appropriateness of applying certain resource management practices to a particular area of land, as determined by an analysis of the economic and environmental consequences and the alternative uses foregone. A unit of land may be suitable for a variety of individual or combined management practices.

SUITABLE
See Commercial Forest Land.

SUPPLY
The amount of an output producers are willing to provide at a specific price, time period, and condition of sale.

SUPPRESSION PROJECTS
Projects administered by the USDA Forest Service, in cooperation with State or other Federal agencies, designed to relieve high western spruce budworm populations in high-value or high-use areas.

SWATH WIDTH
Area on the ground in which the amount of spray equals or exceeds the amount determined to provide effective control.

T

TECHNIQUE
How a basic method is used.

TERATOGENICITY
The capacity of a substance to cause anatomical, physiological, or behavioral defects in animals exposed during embryonic development.

THERMAL COVER
Vegetation that provides wildlife a sheltering effect from climatic conditions.

THINNING
A felling made in an immature tree crop or stand in order to primarily accelerate diameter increment. Also, by suitable selection, to improve the average form of trees that remain, without, at least according to classical concepts, permanently breaking the canopy.

THREATENED SPECIES
Any species listed in the Federal Register, which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

THRESHOLD
This is the point on a dose-response curve, above which effects occur and below which no effects occur.

THURICIDE (R)
Commercial biological insecticide formulation containing the active ingredient, Bacillus thuringiensis.

TIERING
Refers to the coverage of general matters in broader environmental impact statements (such as National program or policy statements) with subsequent narrower statements or environmental analyses (such as regional or basinwide program statements or, ultimately, site-specific statements) incorporating by reference the general discussions and concentrating solely on the issues specific to the statement subsequently prepared.

TIMBER PRODUCTION
The purposeful growing, tending, harvesting, and regeneration of regulated crops of trees to be cut into logs, bolts, or other round sections for industrial or consumer use. For purposes of this definition, the term "timber production" does not include production of fuelwood.

TOLERANCE
Forestry term for expressing the relative capacity of a tree to compete under low light and high root competition.

TOXIC
Relating to a harmful effect by a poisonous substance on the human body by physical contact, ingestion, or inhalation.

TOXICANT
A poison; toxic agent.

TOXICOLOGY
The study of the nature, effects, and detection of poisons and the treatment of poisoning.

TRICHLORFON (R)
Active ingredient found in chemical insecticide formulations sold under the trade name, Dylox (R).

TRUE FIR
Those species of trees such as white, silver, and grand fir located on high-elevation soil sites. A specific ecological plant community.

U

UNCERTAINTY
May be due to missing information, or gaps in scientific theory. Whenever uncertainty is encountered, a decision, based upon scientific knowledge and policy considerations must be made. The term, scientific judgment, is used to distinguish this decision from policy decisions made in risk management.

UNDERSTORY
Vegetation growing under a higher canopy.

USDA
United States Department of Agriculture.

USDI
United States Department of the Interior.

V

VERTEBRATES
Those organisms having a spinal column protected by bone or cartilage.

VIEWSHED
The total landscape seen, or potentially seen, from all or a logical part of a travel route, use area, or water body.

VISIBILITY
How far a given object can be seen by the human eye. The greatest distance in a given direction at which it is just possible to see and identify with the unaided eye in the daytime, a prominent dark object and, at night, a known, preferably unfocused, moderately intense light source.

VISUAL MANAGEMENT SYSTEM
The management system used to protect and enhance the visual resource.

VISUAL QUALITY OBJECTIVE
A combination of inherent scenic quality and public interest which defines the acceptable degree of alteration for any given area.

VISUAL RESOURCE (FOREST SCENERY)
The composite of basic terrain, geologic features, water features, vegetative patterns, and land use effects that typify a land unit and influence the visual appeal the unit may have for visitors. Visual resource categories include Retention (R), Partial Retention (PR), and Modification (M).

W

WATERSHED
The area drained by a river or river system.

WETLANDS
Those areas that are inundated by surface or ground water with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetation or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

WILDERNESS
Lands designated by law as wilderness; no road building or timber harvesting is allowed on such lands; they are intentionally managed to maintain their primitive character.

WILDFIRE
Any wildland fire that requires a suppression response.

WORST-CASE (EXPOSURE)
In the context of this analysis, the worst-case exposure has been defined by adding two standard deviations to the mean exposure. This will set the exposure for a worst-case scenario at the 95-percentile level. Depending upon the variability of the data being analyzed, or the dispersion of values around the mean value, this typically will increase the average exposure levels several times over. For example, the realistic exposure to the general public through drift off-site is 0.00006 mg/kg/day, while worst-case is 0.0003 mg/kg/day or 5 times the realistic dose. (Spill and accident situations are defined separately).

Moth (adult)

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